

INFLATION EXPECTATIONS IN THEORY AND PRACTICE: A SURVEY-BASED APPROACH



MASTER'S THESIS FOR THE DEGREE

Master of Economic Theory and Econometrics

EYVIND SØRAA

UNIVERSITY OF OSLO

DEPARTMENT OF ECONOMICS

MAY 2015

Preface

When working on this thesis, I have received invaluable help from my supervisor Nina Larsson Midthjell, who I always felt had a more complete idea of what I was talking about in the thesis than even me, due to her devoted involvement as supervisor. I therefore wish to thank her for her extraordinary effort, and for giving me the confidence needed to finish this project. I also wish to thank Magnus Larsson and InFact, for lending me their support in designing the survey and collecting the data used in this thesis.

Any errors or omissions in this thesis are my sole responsibility.

Summary

The main purpose of the thesis is twofold, first to provide a review of the literature on inflation expectations, and second, to empirically analyze Norwegian survey data. In the literature review, I trace the role of expectations at various points during the development of macroeconomic theory, to highlight how our understanding of inflation expectations under different circumstances has changed. How inflation expectations should be treated is an unresolved debate in the literature, hence the need for a thorough review. I review some proposals to explain the behavior of inflation expectations, among them expectations models that incorporate learning, sticky information and heterogeneous estimation rules. Among the noteworthy characteristics of measured inflation expectations are that expectations are heterogeneous between demographic groups, and that expectations become more forward-looking when inflation is costlier to ignore. The literature has been concerned with reconciling such facts with theory.

In the empirical part of this thesis, I consider what surveying households can contribute to our ability of pinning down what inflation expectations currently are, and what they tell us about inflation in the future. I therefore analyze empirically Norwegian survey data that concern inflation expectations along three dimensions.

First, I look at the information gathering habits of ordinary households regarding developments in the economy, and the knowledge they possess about inflation dynamics, using a survey designed for this thesis. I find that there is a great deal of uncertainty among the respondents about how inflation will develop over the next twelve months, uncertainty which is perhaps not reflected in the survey measures of inflation expectations in Norway. I also find that many respondents are asked to state their expectations about future inflation without being entirely sure about how inflation is affected by monetary policy, or how inflation is defined.

Second, I examine the predictive ability and rationality of the survey measures of inflation expectations. I estimate by OLS a simple relationship between expected 12 month ahead inflation and realized inflation, to establish whether the survey measures have predictive value. I find that the survey expectations of households are less accurate than those of economists, business executives and labor organizations, especially regarding inflation in prices of domestically produced goods. I then formulate a VAR between the survey measures and realized inflation, in order to test for Granger-causality between the variables. I find

that households' expectations do not Granger-cause inflation, while there is some weak evidence that expectations of businesses and economists do, for some of the inflation measures concerned.

Third, I adopt a model of sticky information, which has as its basic premise that only a share of agents in the economy get access to current information that professional forecasters communicate every period. As a result, the aggregate inflation expectations should contain elements of professional forecasts that date from earlier periods. I evaluate this hypothesis by formulating the relationship between households' expectations and experts' forecasts as an Autoregressive Distributed Lag-model, and find that there is likely a cointegrating relationship between the survey measures, as well as significant lagged dependency, which supports the hypothesis that information is transmitted with a lag to a part of the households in the economy.

Contents

1	Introduction	1
2	The role of expectations in macroeconomic theory	8
3	Low inflation territory: Inflation expectations adrift	16
4	Understanding expectations	19
5	Measuring inflation expectations empirically	25
5.1	Financial market-based inflation expectations	25
5.2	Survey measures of inflation expectations	26
5.3	Evaluating Survey data using experiments	29
6	Empirical analysis of Norwegian survey data	33
6.1	How much do households know about inflation?	33
6.2	Results	35
7	How rational are survey expectations?	42
7.1	Data and stylized facts	42
7.2	Tests for unbiasedness of survey expectations	46
7.3	VAR estimation of inflation and survey expectations	50
8	Relationship between the survey measures	55
8.1	Estimation	57
9	Conclusion	61
	References	64

1 Introduction

The important role of sentiment of economic agents in determining macroeconomic outcomes has been recognized for as long as macroeconomics has been studied separately. Arguably the founder of the discipline, John Maynard Keynes, emphasized how *animal spirits*¹ could be an autonomous cause of fluctuation or a feedback mechanism into the economy (Carroll, 2003). Nowadays the preferred term is *expectations*, and albeit less poetic, it is an equally potent phenomenon. Whether private economic agents' beliefs about the future development of the economy is something monetary authorities should be concerned with has been a contentious issue, and it is only in the past few decades that their significance for the actual development of the economy has been appreciated, as well as their essential role in any government's attempts to actually influence that development.

When individuals and businesses make economic decisions, they are aware that they will have to stay by their decisions long into the future, living with the consequences of their decisions, good or bad. It is therefore essential to try to imagine how future economic conditions will be, because these conditions measure the soundness of their decisions. Future inflation is especially salient to the agents. The cost of repaying a loan to finance housing or a business investment is greatly affected by how much prices increase in the mean time. Given a constant interest rate and a loan principal given in nominal terms, higher inflation will make the value of the debt smaller. For this reason, it is the *real interest rate*, i.e. the nominal interest rate minus expected inflation, that matters when economic decisions are made. A higher expected future inflation makes the real interest rate lower, which makes it more attractive to take up credit and undertake investments, increasing the activity in the economy.

Not only new debt-financed investments, but also the vast stock of private debt, which is one of the pillars of the modern economy, is hugely affected by changes in the expected future inflation. If expected inflation is reduced, causing a higher real interest rate, taking up a mortgage to buy a house will be less desirable. The effect will be that house prices fall, or increase less than they otherwise would. Existing mortgages will therefore have a lower Loan-to-Value ratio² than before, increasing the debt burden on the debtors.³ Because the

¹Keynes put large emphasis on the sentiment of investors, who could be swayed by “animal spirits” in waves of optimism or pessimism, creating booms or recessions by moving in unison.

²Usually, banks will only allow a mortgage loan that is a certain fraction of the value of the property, leaving debtors to finance part of the investment with their own savings. This fraction is the Loan-to-Value ratio.

³In the extreme, such as during the Subprime crisis in the US, when little collateral was required, some

price level will be lower than it otherwise would be, the real value of debt in the economy will be larger, leaving less room for other expenses and making the economy suffer. Restrictive, *leaning against the wind*⁴, monetary policy has been justified for reasons of financial stability, but the mentioned effect could imply that these policies are partly misguided (Svensson, 2013). In many countries inflation has been exceptionally low during the last few years, meaning the weight of the debt burden could be added to the economic hardships experienced partly due to austerity policies.

Another way that expected inflation impacts the economy is through the exchange rate. Higher expected inflation at home than abroad will reduce the future real value of capital, and thereby reduce the return on investments at home, leading investors to seek higher returns abroad. As a result, the demand for the local currency will fall, requiring a depreciation of the currency's exchange rate against other currencies for supply and demand to coincide. The exchange rate is lower than before, or in other words, one unit of local currency can buy a lesser amount of foreign currency than before. This means the price of goods produced abroad measured in the local currency will be higher, increasing the price of all goods imported from other countries. As a result, *imported inflation* increases, increasing the general level of prices. In addition, a lower exchange rate means exporters at home enjoy higher competitiveness because the world prices they receive for their products translate into a higher amount of local currency. To the degree that producers do not depend on imported inputs in their production, the cost of production, e.g. labor costs, stay relatively constant. The increased competitiveness encourages higher production and demand for labor and capital, and increases activity in the economy. This will eventually also lead to higher inflation, meaning the increased competitiveness is temporary.

The central bank is the custodian of the links between the present and the future in the economy. Among other things, it issues the money that allows trade to be separated in time, and control the terms at which we can save money for the future in bank accounts. Expectations are therefore especially salient for the central bank. For a long time, however, central banks had no intention of affecting agents' expectations by making their operations understandable.⁵ The past two decades have witnessed a radical shift in the direction of more

debtors could be left "under water", that is, their debt was larger than the value of their houses.

⁴Leaning against the wind refers to counter-cyclical policy aimed at dampening a rapid expansion (or contraction) of activity by posting a higher (lower) interest rate than what would be warranted in a more stable situation, to extinguish any asset bubbles that might arise. In many countries where inflation is very low, a policy of leaning against the wind entails higher interest rate than what the concern for inflation in isolation would suggest, to contain financial instabilities that might arise due to low costs of financing.

⁵Alan Greenspan admitted to purposefully "mumble with great incoherence" (Blinder, Ehrmann,

monetary policy transparency. Before rational expectations took front seat in the literature, the efficacy of monetary policy actions was thought to depend on an unsuspecting public. It was thought that the government could take advantage of the trade-off between inflation and employment by administering *surprise inflation*. This is no longer a widely held view. Instead, monetary policy has come to be about convincing the public that the central bank will succeed in its plans. The immediate effects of ECB Governor Mario Draghi's statement that he would do "whatever it takes" to save the Euro in 2012, and then Fed Governor Ben Bernanke saying the Fed would do "everything possible" to restore the economy in the wake of the financial crisis, are testament to the importance of expectations on monetary policy effectiveness. The reason why statements such as these have such incredible effects is that they not only reveal what actions will be taken *today*, but delivers a convincing commitment that those measures will be upheld into the *future*. Central banks only have direct control over the interest rate on short term instruments such as the overnight deposit rate, therefore, as Blinder (1999) points out, managing expectations is key to gain influence over longer term interest rates:

"Expectations about future central bank behavior provide the essential link between short rates and long rates. A more open central bank ... naturally conditions expectations by providing the markets with more information about its own view of the fundamental factors guiding monetary policy..., thereby creating a virtuous circle. By making itself more predictable to the markets, the central bank makes market reactions to monetary policy more predictable to itself. And that makes it possible to do a better job of managing the economy. " (Blinder, 1999, cited in Blinder et al., 2008)

Especially when interest rates approach their zero lower bound, as they have in many countries since the start of the Great Recession, the ability to influence inflation expectations is a valuable asset, since real interest rates would be lower the higher the expectations. With nominal interest rates close to zero, this is the only way of reducing the real interest rate. Unconventional monetary policy in the aftermath of the Great Recession, such as quantitative easing measures taken by the US Fed and the BoE, is meant to have an influence on long term interest rates, which are important determinants of future economic conditions. If the central bank through its unconventional measures can convince economic agents that

Fratzscher, De Haan, & Jansen, 2008). Paul Volcker, in his time as Fed chairman, defended the limited communication issued by the Fed by arguing that communication commits.

future interest rates will be low, they will look more favorably on the future prospects of the economy, and revise their inflation expectations upward.

Also in the functioning of conventional monetary policy, inflation expectations have been assigned major importance, and have been recognized as one of the central transmission mechanisms of monetary policy (Armantier et al., 2011). By managing the public's expectations, central banks can increase the effectiveness of their policy instruments for stabilizing the economy, and better achieve their long term goals of price and financial stability. Committing to an inflation target has gained almost universal support as the best way of achieving these goals. There is a wide consensus in the literature that implementation of inflation targets resulted in consistently lower inflation rates in countries that adopted them (Mishkin & Schmidt-Hebbel, 2007, Vega & Winkelried, 2005, Hyvonen, 2004).⁶ Studies also show that inflation expectations are better anchored, i.e. expectations do not change much even though inflation might fluctuate, in countries with inflation targets than in others (Ehrmann, 2014 Levin et al., 2007). While other types of targets can also accomplish a low and steady price growth, an inflation target has the advantage that it is easy to understand and that it focuses attention on the target. This is especially important, considering the independent effect that expectations has on the economy.

There are drawbacks of openness, however. Announcing too soon what policy measures are to be taken can make them take effect sooner than desired. US Fed vice-chairman Stanley Fischer recently argued that the exceptional forward guidance that has been provided by the Fed during the Great Recession should be toned down as the US economy approaches normality (Applebaum, 2015). Fed representatives have adamantly refused to give any precise date for interest rate increases, only saying they are conditional on growth and inflation reaching a robust level.⁷ Some smaller central banks (in Norway, Sweden, New Zealand, and the Czech Republic) also publish forecasts for the key policy rate, which

⁶One argument against view is that early adopters of inflation targeting had fiscally prudent governments and central banks that were reputable in advance, which in itself would make it easier to reduce inflation from high levels that were seen as unsustainable (Johnson, 2002). Alternatively, countries with high rates of inflation found it necessary to implement a target that commits, and regression towards the mean made these countries reduce inflation rates quicker than others. Both of these explanations are in essence that the choice of implementing an inflation target was an endogenous choice.

⁷In March 2014, Fed Governor Janet Yellen revealed that the Fed considered six months after bond-buying programs (QE) end is an appropriate time schedule for when interest rate increases should commence, whereas previously the most precise time frame the Fed would admit to was "considerable time after." In an attempt to lessen the character of forward guidance of the wording used by the FOMC, they have replaced the reference to an unspecified future date with the even less specific promise of having "patience" in regards to rate hikes. In March 2015, this term was subsequently removed, which made observers think interest rate increases are soon to be expected. Governor Yellen dismissed these conclusions.

undoubtedly clarifies the intentions of the central banks moving forward, but runs the risk of selling the public an interest rate path that is subject to change when unanticipated shocks hit the economy. As these examples illustrate, optimal communication of central banks is situationally dependent.⁸

All things considered, central banks should limit themselves in how much information they communicate, as there are limits to how much information agents can digest (Kahneman, 1973), and the noise that distort the main message will be more severe the more information agents have to sift through (Blinder et al., 2008). In addition, the central bank's information set itself is plagued with noise, e.g. with respect to the construction of the output gap and the identification of shocks. If the central bank has limited information, communication could be counterproductive. However, the central banks do spend vast resources on monitoring the economy, more than any other party, and has the public's ear, which suggests that well-crafted communication should be one of their main preoccupations. When it comes to the central bank's intentions and planned actions, no one is better informed than the central bank.

Managing expectations is to a large degree about securing long term price stability and making sure expectations are anchored on target, but it will also play a role for policy in the medium term where the issue is how to counteract shocks to the economy. Svensson (1997) points to the non-feasibility of targeting inflation in itself, as monetary policy has a lag of one to three years before it takes effect, making it difficult for central banks to react to shocks in a timely manner. Instead, he shows that an inflation target is equivalent to an intermediate forecast target, where the aim is to get the central bank's forecast for future inflation to line up with the inflation target. This makes it less important to emphasize in communication that the efforts to achieve the target will take effect gradually, as the time it takes for inflation to move towards the target is built into the inflation forecasts. This does however make precise forecasts crucial, and where forecasts of inflation is concerned, theory tells us that it is *expectations* that is the deciding factor. The central bank's ability to make good forecasts of inflation depends on its capability of understanding what determines the public's inflation expectations (Bernanke, 2007).

When executing monetary policy, a big challenge for central banks is to cross the divide between theory and practice. Because the real world is infinitely more complex than any economic model, there is no clear cut transmission between monetary policy bank lending

⁸See Dieffenthaler (2014) for further discussion of central bank communication.

and market interest rates that central banks can say with certainty will behave in a specific way. Instead, monetary policy is performed in incremental fashion, measuring the effects, then evaluating the need for additional efforts. Likewise, there is no obvious way of measuring many of those variables that monetary policy is guided by, such as the output gap. This applies particularly to inflation expectations, which is an especially fleeting concept. Whose inflation expectations is the most important? Should we take the conclusions from theory to heart, and consider inflation expectations to be a disaggregated phenomenon that comes about in the process of every agent's optimizing behavior, which means we should go directly to the source and give equal weight to each individual's beliefs, or should we let the more practical aggregate market indicators guide us, which have to abide the strict judgment of market forces and therefore provide an honest measure of expectations? In the first case, surveying individuals indiscriminately seems like the way to go to acquire a measure of what inflation expectations are. In the second case, methods exist to derive inflation expectations from market instruments that protect the investor from the risk of inflation. If these do not exist, as in Norway, a decent proxy could be to survey experts who have a close ear to the economy, such as economists and analysts in the financial industry, business and academia.

The main purpose of the thesis is twofold. First, I trace the role of expectations at various points during the development of macroeconomic theory in past decades, to highlight how our understanding of inflation expectations under different circumstances has changed. Disagreement about how to treat inflation expectations in the behavior of agents and variables in the economy is a thread that runs through this entire history. No consensus has been reached in the literature, I therefore present a thorough literature review that seeks to relate the differing views to each other. Along with the increased attention given to inflation expectations by market participants and central banks in later decades, the increasing availability of data has allowed for research that better our understanding of how inflation expectations are formed. I look at how this has reflected back at the modeling of macroeconomics, what challenges it has revealed for our ability to measure inflation expectations accurately, and how we can obtain a better understanding of the formation of inflation expectations.

Second, a question that motivates this thesis is what surveying households can contribute to our ability of pinning down what inflation expectations currently are, and what they tell us about inflation in the future. I therefore analyze empirically Norwegian survey data that concern inflation expectations along three dimensions. First, I look at responses from a

one-time survey designed for this thesis, where I ask respondents about their knowledge of what goes on in the economy, as an informal test of many of the assumptions that is standard fare in macroeconomic theory, e.g. rational, forward-looking expectations. The aim is to examine whether there are benefits in measuring inflation expectations by surveying indiscriminately, by targeting households as respondents. I find that a large share of respondents does not seem to possess the information, or knowledge needed to give a rational forecast of inflation. Second, I analyze survey data from the largest Norwegian survey on inflation. I use established methods to determine how accurate the survey forecasts are, with a special emphasis on those of households. I examine the accuracy of survey forecasts by OLS, before I look at the dynamic relationship between survey measures of expectations and realized inflation in a VAR setup. The data allows me to separate between the expectations of households, economists, businesses and labor organizations, which makes it possible to evaluate the relative accuracy of the different groups. It is reasonable to assume that the three latter groups possess more information and knowledge about what determines inflation, leading me to expect that these groups' forecasts are more accurate than those of households. I find that there is little correspondence between households' survey expectations and inflation, while economic experts, business executives and labor organizations are better able to forecast inflation, and particularly movements in inflation that are determined by fundamentals in the economy, i.e. the parts of CPI that consist of prices on domestically produced goods and services. Third, I pursue a hypothesis stemming from the literature on sticky information, proposing heterogeneity in households' inflation expectations because of information slowly dispersing in the economy. Current information is assumed to originate from professional forecasters, and then circulated to households through news outlets. Because the absorption of new information is not perfect, the hypothesis is that households' expectations contain elements of past inflation forecasts made by experts. I perform a test of a cointegrating relationship between experts' forecasts and households' expectations, and find that expectations do move towards the forecast, suggesting a relationship where information is distributed with a lag. I interpret this as support for the theoretical model of sticky information that I adapt.

The rest of this thesis is structured as follows: In section 2, I review the role of inflation expectations in macroeconomic theory throughout its history. Recently, low interest rates combined with low inflation has posed a conundrum for central bankers in many countries. In section 3, I review the literature concerned with how inflation expectations can contribute to

such problems and how expectations formation will itself be affected. Section 4 presents some alternative models of expectations which start out from behavioral assumptions that detract from rationality, to meet the limitations of theory in explaining inflation. In section 5, I look at how inflation expectations are measured using market data and surveys. This section also sheds light on methodological problems that arise when measuring inflation expectations. In section 6, I analyze a cross-sectional data set of Norwegian households, before I in section 7 analyze the forecasting ability of the largest Norwegian inflation expectations survey. I do further analysis in section 8, concerning relationships between the survey measures. All analysis in this thesis is performed using Stata or SPSS. Section 9 concludes.

2 The role of expectations in macroeconomic theory

I opened this thesis with a reference to Keynes' (1936) pioneering contribution to macroeconomics, because of the central role he appointed to expectations in explaining booms and busts. Theorists both before and after have also had to account for the effect that expectations have, in one way or another, which I seek to provide an overview of in this section.

Macroeconomics as a discipline was born out of the Great Depression, when the persistent slump in demand and high unemployment rates all over the developed world left a lasting impression on generations of regular people and academics alike. Before then, the reigning principle in discussions of the macroeconomy was Say's Law, postulating that supply will create its own demand. According to Say (1855), agents in the economy will offer goods for sale because they in turn want to buy other goods. Money only serves the purpose of a temporary means of exchange, a savings glut can therefore not occur. There can be no supply above demand. If there is unemployment, it is because there is a lack of specific specialized labor, and an abundance of labor of other types.

J. M. Keynes argued forcefully against this belief in his *General Theory of Employment, Interest and Money* (1936). There, he pointed out that for long periods of time, consumers and businesses could refrain from undertaking investments and rather hold on to their money, because of expectations that spending the money now would yield less utility than simply stuffing it in the mattress. In an environment where the outlook of future returns on investments are bad, the usual assumption that savings equals investments might not hold. In addition, because of the *multiplier effect*, decreased consumption and increased

saving can lead to a contraction in output and eventually a reduction in saving itself, the so-called *paradox of thrift*. Keynes' most important message was that when private demand failed, the government should step in and cover the shortfall by launching public works programs and ease the conditions businesses face for undertaking investments, and institute automatic stabilizers such as unemployment insurance. Central banks, while still beholden to the fixed exchange rate system of the Gold Standard, and later Bretton Woods, should have some room for accommodative monetary policy. Keynes argued that what mattered for economic agents considering whether to undertake an investment was the real interest rate they faced, i.e. the nominal interest rate minus expected inflation. The job of the government in a downturn, according to Keynesian macroeconomics, is therefore to raise inflation expectations and lower real interest rates, making investment more attractive. This relationship is epitomized by the *Phillips curve*.

Looking at historical records, Phillips (1958) found that there was an inverse relationship between inflation rates and unemployment. The implication was that governments could combat unemployment by allowing for higher money growth and higher inflation. The Phillips curve has therefore been seen as underlying the program of inflationist policy-makers in the late 60s and early 70s. The increased confidence in the methodological advances in econometrics and optimal control found its expression in the governance philosophy of *New Economics*, which prescribed active fiscal and monetary policy to achieve full employment of economic resources (Orphanides & Williams, 2005). Quite to the contrary, the early 70s was characterized by *stagflation* in the US, with high unemployment and double-digit inflation. Some contest that the interpretation of the Phillips Curve that the inflation-unemployment trade-off could be exploited for lasting efficiency gains was the consensus among economists (Forder, 2010), rather holding the view that this portrayal of the economics profession at that time made a convenient target for the dissidents who would later come to the fore.

Probably the most famous critic of the adherents to the Phillips curve proposition was Milton Friedman (M. Friedman, 1968), who asserted that the relationship would only hold in the short run. Friedman offered an early argument of the importance of expectations for the economy, by emphasizing the difference between *anticipated*, ex ante, values of variables, and *realized*, ex post, values. A discrepancy between them would eventually lead agents to revise their anticipation. Friedman thus introduced the concept of *adaptive expectations*. Friedman applied Wicksell's (1936) notion of a *natural rate of interest* to unemployment. At any time there is an equilibrium of the employment rate and real wages given by the

fundamentals of the economy. Maintaining employment at this level will make real wages increase at a rate consistent with capital accumulation and productivity. Using monetary or fiscal policies to lower unemployment below this rate will result in upward pressure on real wage rates. The consequent increase in demand will make the prices of finished goods and services increase as well, which is a prerequisite for the extra demand for labor given that production costs increase. So far, this is in line with the Phillips curve predictions. However, workers will come to realize that the price increases neutralize their higher income, leading to higher wage demands. Since wages are only adjusted at low-frequent intervals, less often than prices on finished goods, a situation where unemployment is below the natural rate can persist for a while. Expectations of future prices matter for the workers' demands, however, so if the policy is maintained, workers will get ahead of the curve, and close the gap between production costs and goods prices. At those terms, it is no longer profitable for employers to hire the extra labor. That is, in the long run, governments can create as much inflation as they want, unemployment won't budge from the natural rate; the Phillips curve is vertical.

Another, related, line of attack against the classical macroeconomics that was launched during the 1960's concerned the degree of understanding that economic agents had about how the economy worked, and how this, in turn, influenced the working of the economy. Muth (1961) was an early proponent of assuming *rational expectations* among agents. His and others' critique of traditional macroeconomics was that economic models lacked a description of the process by which economic agents acquire knowledge and use it to form expectations about economic development (B. M. Friedman, 1979). The main problem was that the models only treated the relationship between *aggregate variables*, without taking a peek at the underlying processes that defined the aggregate relationships. Muth (1961) and others argued that the unit under analysis should be the *individual decision maker* in the economy rather than the economy as a whole, because the economy is the sum of individuals' actions. On this backdrop, Muth (1961) introduced the idea that economic agents have an economic model in mind when making economic decisions. All information available to the agents is used to model the economy, correctly calculating the behavior of consumers and government agencies on the basis of their objective functions. Subsequent research has retained this definition of rational expectations. Although Muth (1961) held that this was not necessarily an accurate description of how the economy really worked, he defended the assumption on the grounds that on average, expectations will be accurate. It is also argued that in the aggregate, better informed agents will exploit any opportunity of arbitrage so

that the result predicted by the model comes about in the end.

Assuming rational expectations implied that individuals were *forward-looking* rather than backward-looking in forming expectations. Agents with backward-looking expectations infer a model of the economy that they can piece together from their observation of how variables behaved in relation to each other historically, while agents with forward-looking expectations know the true model of the economy and use only the most recent information about relevant variables to form their expectations. In this way, the agents would not make systematic errors in their predictions, the only deviation from the realized variables would be stochastic errors realized after expectations had formed.

Muth (1961) especially points to the tractability of letting the same general assumptions apply to different dynamic problems, instead of more ad hoc assumptions about how expectations are formed. Rational expectations could be incorporated in all models in a general way.⁹

An especially prescient critique against the hopes of fine-tuning the economy using econometrics to design policy was levelled by Lucas Jr (1976), who pointed out that the behavioral patterns of individual consumers and firms could not be assumed to stay constant when policy changed. The estimation of economic systems using econometrics relies on historical data to uncover the relationships in the economy. Policy changes, however, like instituting a tax, constitute *structural breaks* that make past realizations of the variables uninformative about what the effect of the policy change in question will be. The aggregate variables are determined at the individual level, and expectations adjust according to the changing environment. The *Lucas-critique* therefore does not only condemn the practice of taking a birds-eye view of the macroeconomy, but provides hope that the aggregate relationships can be well understood if they are only analysed from the ground up. Deriving macroeconomic models from *microeconomic foundations* was the obvious solution, something which fit the increasingly technical tool-kit of economics well. A representative agent is thought to optimize at every point in time taking state variables as given, which determines variables such as wages and prices in equilibrium. As a result, prices should be completely *flexible*, without frictions that would hinder them from taking the optimal values. This means expectations leave no role whatsoever for monetary policy to affect the business cycle. If the central bank would issue more money to try to stimulate the economy, private agents immediately react

⁹Additionally, if theory or evidence suggest different processes of expectations formation, there is every possibility for assuming a combination of rational and backward-looking expectations.

with a corresponding change in prices, making money completely neutral. This is a feature of the class of growth models called *Real Business Cycle* (RBC) models, where, as the name implies, goods and services are always traded at their real values.

The assumption of rational expectations has even more damning implications for the optimism of the Phillips curve than Friedman’s critique. The *natural unemployment rate* argument was taken further by Barro and Gordon (1983), showing that an *activist* central bank, targeting unemployment at a lower level than the natural rate, would be exposed immediately by rational agents. Having rational expectations, they would anticipate the attempts of *surprise* inflation by central banks seeking to increase the activity in the economy. By increasing inflation by surprise, profit margins of firms would increase, making it more attractive to hire and produce more. Rational agents will expect this higher inflation, and demand higher nominal wages to offset higher prices, leaving no room for surprises, and the end result would only be higher inflation and unchanged unemployment. This was the origin of the concept of an *inflationary bias* in the central bank’s objective function, which is stronger the more the central bank tries to reduce unemployment below its natural level, and set the ball rolling in the discussion on whether central banks should be *independent* – to be free of political pressures, run by a conservative governor (Svensson, 1995, Rogoff, 1985), and operate according to rules rather than discretion (Kydland & Prescott, 1977).

The introduction of micro-foundations and rational expectations in macroeconomics certainly improved the mathematical elegance of the models. However, the huge influence of its proponents on the economic literature notwithstanding, the assumption of rational expectations has not held up very well to the mounting empirical evidence on expectations formation (Armantier et al., 2011).

As discussed, RBC models that have rational expectations as its central feature leaves no room for monetary policy. All practical experience show that central banks actually do have the power to influence the economy to a certain degree. The reason that monetary policy is effective is because of the *persistence* of inflation. Persistence in this context means that the variable is dependent on its own history, in the form of lags in a regression framework. Gordon’s (1982) triangle model of inflation incorporates this element:

$$\pi_t = \sum_{s=t}^T a_s \pi_{s-t} + b(U_t - \bar{U}) + c\chi_t + \epsilon_t \quad (1)$$

Here, inflation is dependent on its own lags, understood as working through backward-looking, *adaptive*, expectations, as well as the *unemployment gap*, a measure of real activity, and supply side variables summarized in χ . ϵ_t is a shock to supply, with zero mean. While in RBC-type models the real interest rate is determined by the optimizing behavior of the agents, the central bank now has an influence over the real rate when expectations are adaptive, since the price level does not react one to one with a change in the policy rate, neutralizing the policy rate's effect on the real rate. Since the real interest rate is a determinant of demand for consumption and investment, the central bank can thereby affect the activity level in the economy, at least in the short run. Accordingly, models with adaptive expectations do not suffer from neutrality of monetary policy. As discussed earlier, however, adaptive expectations are unsatisfactory when trying to model realistic dynamics of the economy.

One way of incorporating rational, forward-looking expectations in models while keeping the central bank's ability to influence the economy intact has been to assume *rigidities* in the price-setting behavior of otherwise rational, optimizing agents. The most common way of doing this has been to apply staggered Calvo-type pricing, either in wages, goods prices or both (Calvo, 1983). The simple story is that only a fraction of firms are allowed to change their price at any given point in time. The average price level is therefore a combination of updated and past prices. The agents take into account that they will have to wait to adjust their prices again, setting a price that is as close to optimal for the whole period they expect to have to wait. The appeal of this method is that “sticky” prices can be observed all over the real economy. The median interval for price changes of firms is one year in the US (Mankiw, 2001), and 9 months in Norway (Erlandsen, 2014). Because the use of sticky-price models have restored focus to the demand-side of the economy, as well as allowing for non-neutrality of monetary policy that was a characteristic of classical Keynesian models, research that build on them has been classified as *New Keynesian*.

A standard New Keynesian inflation equation differs from the classical Phillips-curve in that the dependence on the past is gone. As seen in equation (2), only expected inflation matters, along with the *output gap*, \tilde{y}_t ,¹⁰ and the disturbance ϵ_t which encapsulates supply, or *cost-push*, shocks:

¹⁰Like the unemployment gap, \tilde{y}_t is a measure of real activity. The output gap is defined as the difference between actual output and *potential* output, the level at which the economy is said to be at full capacity.

$$\pi_t = \beta E_t \pi_{t+1} + \gamma \tilde{y}_t + \epsilon_t \quad (2)$$

While New Keynesian models with sticky prices take care of the issue of monetary neutrality, they cannot properly explain the *persistence* of inflation. The staggered price setting clearly give some persistence to the price level, but the rate of change in the price level – the inflation rate – can nevertheless change instantly. Because inflation persistence is such a recognizable feature in all inflation data, a theory that does not account for it is unsatisfactory.

With backward-looking expectations, as was assumed in the traditional Phillips-curve relationship, inflation persistence is very much present. When shocks hit the economy, and the central bank reacts by changing the policy rate, the rate of inflation could be slow to adjust. In rational expectations models however, history should play no role, and inflation should therefore react instantaneously to the changed economic environment.

Sargent (1982) pointed to the sudden end of four cases of hyperinflation as an argument for the presence of rational expectations. In these cases, persistence in inflation seemed to disappear immediately when the fundamentals of the economy changed. The extremely high rates of inflation of these cases set them apart from the experience of most central banks in recent times, where the issue is rather how to control inflation rates that are moderate or even very low. The smooth, continuous behavior of various inflation measures, such as the Consumer Price Index (CPI) in the post-war period, does not go well along with the assumption that prices are completely flexible. There is indeed quite strong evidence of persistence in US inflation over the period from 1960 to 2000. Persistence in other variables could account for part of the inflation persistence, but not all of it. After 2000, however, the persistence in inflation became very small and almost non-existent (Fuhrer, 2009).¹¹

The New Keynesian models are also plagued with some other issues that it is difficult to reconcile with the data. For instance, in a sticky price model, the central bank can create a disinflationary episode that leads to an output expansion, if it credibly announces the disinflation beforehand. This works because agents that are informed of the central bank's intentions will start lowering their prices immediately, as well as inflation expectations,

¹¹Fuhrer (2009) defines persistence as first order autocorrelation, i.e. the variable's dependence on its value in the previous period. Mathematically expressed by an AR(1)-process: $v_t = \rho v_{t-1} + \epsilon_t$, where $\rho \in (-1, 1)$ ensures stationarity. ϵ_t is a white noise error term. Fuhrer (2009) finds that the AR-1 coefficient was between .5 and .8 between 1960 and 2000, and .2 after 2000.

reducing inflation before the central bank starts reducing the money supply. This increases real money balances in the economy and increases activity (Mankiw & Reis, 2001). In reality, however, disinflation is associated with an output contraction. Furthermore, New Keynesian models do not feature the considerable lag that exists between monetary policy actions and their effects. There is no consensus on how long this lag is, and it will vary under different circumstances, but estimates vary from one to three years passing before monetary policy actions have their peak effect (Batini & Nelson, 2001).

Despite these drawbacks, the New Keynesian models have gained a prominent position in the literature. It is reasonably successful in duplicating the path of inflation when fed with economic data, and most of its dynamics is consistent with how we know monetary policy affects the economy. It features a short run trade-off between inflation and output stabilization in the presence of supply shocks, while monetary policy is neutral in the long run. It provides some important lessons to central bankers, most importantly that monetary policy is most effective when successfully managing inflation expectations.

Different estimation methods have been employed for New Keynesian parameter estimation and out of sample forecasting. New Keynesian models were from the start estimated as a system of simultaneous equations, i.e. as Dynamic Stochastic General Equilibrium (DSGE) models, but limited-information methods, such as GMM,¹² has become increasingly popular methods of estimation (Roberts, 1995). The advantage that such limited-information methods do not impose a structure on any other equation than that of interest, thereby reducing the chance of mis-specification, outweighs the disadvantage of less precise estimation results.

The problem that inflation expectations are not directly observable has been tackled in various ways. Some have simply replaced expectations with realized values, as expectations are assumed rational. Instrumental variable techniques have also been used, with lagged inflation serving as instruments. Survey data provide a (crude) direct measure of inflation expectations. Estimating a New-Keynesian Phillips curve using survey data was introduced by Roberts (1995).

Nowadays, central banks use a wide variety of models to monitor the effect of monetary policy and to forecast future inflation and output. These models typically contain a source of sticky prices, leaving a role for monetary policy. A wide variety of different processes

¹²Generalized Method of Moments (GMM) is an estimation method that rely on a set of *population moment conditions* which derive from the econometric model. GMM requires fewer assumptions than methods that rely on maximum likelihood estimation, where a full description of the data generating process and correct specification of the model is required.

with which expectations are formed is on the menu; rational expectations are not the only option.

As this review has shown, the themes that at any time have been given most attention by macroeconomic theorists are highly correlated with which trends are most prominent in the macroeconomy at the same time. Examples of how this has shaped theory is the focus on the demand side of the economy after the Great Depression and in the post war-era, and the 180 degree shift towards supply side issues during the stagflation of the 70s. Theoretical advances today take many cues from experiences of the Great Recession, and one poignant challenge that has presented itself for theory is persistent low inflation in spite of low interest rates. The next section describes how this has been addressed in the recent literature.

3 Low inflation territory: Inflation expectations adrift

Adopting an inflation target does not guarantee perfect coincidence between inflation and the target. Periods where inflation is considerably above or below the target have often occurred. With the large credibility gains that come from professing to and achieving the inflation target, come potential losses from having inflation drift away. Following the Great Recession, many advanced economies are now experiencing persistently low inflation, even risking deflation, at the same time as interest rates are at record lows and growth only seems to be picking up slowly. Will the low inflation lead to lower confidence that central banks can reach their inflation target, causing expectations to become unanchored? Central bank communication, explaining the gap between expectations and the target and sketching possible policy reactions can help guide expectations back to target, if the information provided is regarded as new information and the communication is credible.

Corder and Eckloff (2011) find that short- and medium-term inflation expectations in 14 inflation targeting countries do drift away from target in a sample of 23 episodes where inflation showed a sustained deviation from target of at least 18 months between 1994 and 2011. This suggests that central banks might want to go to exceptional steps to jerk the economy out of a period with off-target inflation. Otherwise, the central bank's vigilance in achieving its stated inflation target might be questioned, which would hurt credibility and make monetary policy actions less effective. Worse, it could weaken the inflation targets gravitational pull for expectations. As a great deal of realized inflation is determined by expectations, letting inflation expectations drift away from target might lead to a self-

reinforcing spiral where the drift in expectations gain momentum. Across the many cases of off-target episodes studied by Corder and Eckloff (2011), medium-term inflation expectations seem to move gradually in the direction of deviation from target. Median inflation expectations in the sample deviates in absolute value by one percentage point 12 months into such an episode. It becomes increasingly costly for central banks to make expectations revert back to target the longer the off-target periods last. It is a reasonable assumption that this danger is reflected in central bank's behavior.

Neuenkirch and Tillmann (2014) allow for a tougher central bank response to prolonged off-target inflation in a modified New Keynesian model. They assume that expectations are partially forward-looking and partially backward-looking, and the weight of the backward-looking element depends on the credibility of the central bank, which again depends on past performance on hitting the inflation target. As a result, sustained periods of off-target inflation makes expectations more backward-looking, and hence less strongly anchored and harder to influence with monetary policy. The optimal interest rate rule is a nonlinear rule that calls for sharper reactions when past inflation has deviated from target. In addition to adjusting the policy rate to present deviation from target, it should also be adjusted to deviations from target in earlier periods, to counteract the credibility loss, i.e. how strongly expectations have become backward-looking. The authors call this a credibility loss term in the interest rate rule, which existence they find support in a sample of five inflation targeting central banks (Neuenkirch & Tillmann, 2014).¹³

They estimate the size of the credibility loss term separately for episodes of negative and positive deviations from target, and find a larger term when deviations from target are negative, suggesting that worries of letting inflation expectations fall loom larger than expectations drifting upwards (Neuenkirch & Tillmann, 2014). A possible explanation is that fear of deflation will lead to strong responses to inflation rates that inch towards zero.

An implication of the results in this study is that announcing a policy target has to be followed up by achieving it for it to be credible. It also means central banks, after prolonged periods of off-target inflation, as has been experienced during the Great Recession, might have to deal with a considerable credibility loss, that lessens the effect of monetary policy.

In a similar vein, Ehrmann (2014) asks whether the formation of inflation expectations under persistently low inflation is different from when inflation is high. Using monthly survey expectations data from a panel of 14 inflation targeting countries and the euro area

¹³Sweden, the UK, Australia, New Zealand and Canada.

as a whole, his analysis shows that when inflation has been low for a prolonged period, 12 months ahead inflation expectations become more backward-looking. This implies that although inflation expectations are anchored on target on average, it will take longer for them to return to target after a deviation. Ehrmann (2014) also shows that forecasters disagree more when inflation is persistently low, suggesting inflation expectations are less strongly anchored. Inflation forecasts are revised downwards when inflation is lower than expected, but is not revised upwards when inflation is higher than expected. Furthermore, if inflation strays away from the target, either upwards or downwards, disagreement increases in inflation targeting countries, implying that there is an effect of moving away from the target in either direction. Combined, the results suggest that inflation expectations returns to target at a slower pace in an environment of low inflation.

An interesting example of inflation drifting away from target is found in Sweden, where inflation and growth has been low for a long time. The central bank has until recently nevertheless been following a policy of leaning against the wind to calm potential financial instabilities.¹⁴ As a result, the policy rate has been kept higher than what would be optimal if only the inflation rate and the output gap was considered. Letting inflation drop below target – and at the same time anchor inflation expectations on target – is in itself bad for the economy in that it raises real debt levels in the economy (Svensson, 2013). Increasing the real debt level implies a wealth transfer from debtors to creditors, and lowers expected future disposable income because debt servicing becomes more expensive, not ideal for economies struggling to climb out of recession.

If, on the other hand, inflation expectations start to follow inflation downwards, the central bank might have an even larger problem on its hands. As mentioned earlier, expectations of moderate inflation make it more attractive to undertake investments financed by taking up credit, and spend money now rather than later, increasing today's inflation. If inflation expectations no longer provide this service, central banks have to do the job of getting inflation back on track by lowering interest rates more. In many countries, rates are already zero, and some are venturing into negative territory. Low inflation thus threatens to become a very unshakable phenomenon, which reinforces itself by worsening sentiment and future outlooks for growth.

Because of these experiences, which show that expectations formation is situationally dependent, a better understanding of how inflation expectations are formed is even more

¹⁴For definition of leaning against the wind, see footnote 5.

important. The efficacy of monetary policy is conditional on the manageability of expectations, it is therefore highly useful for central bank's to know whether, and how, expectations can be managed. In the next section, I present some of the advances in different ways of modeling expectations formation, which start out from other assumptions than the rational expectations tradition.

4 Understanding expectations

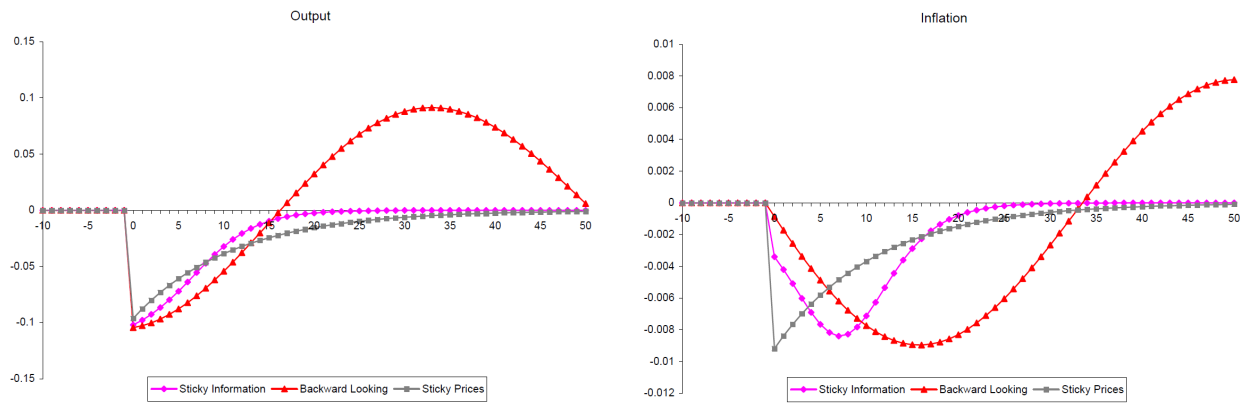
The review of how expectations enter into theory in section 2 reveals that although expectations are omnipresent in economic dynamics, we don't have a full understanding of them. Because the variable is unobservable, we have to rely on approximations that start out from some general assumptions. Various attempts at doing this has had rational expectations as their point of reference, but the way their underlying assumptions differ from rationality allow them to explain different aspects of how expectations behave. The sum of the insights that these different proposals provide can increase our understanding of how inflation expectations form. That is something which is valuable in itself, as Ben Bernanke has expressed it: "A fuller understanding of the public's learning rules would improve the central bank's capacity to assess its own credibility, to evaluate the implications of its policy decisions and communications strategy, and perhaps to forecast inflation." (Ben Bernanke, cited in Armantier et al., 2012).

Different processes of expectations formation have been applied in attempts at estimating macroeconomic models in the literature. Among them are models with *sticky information* (Mankiw & Reis, 2001), in which the most recent information slowly disseminates into the economy. The idea is that only a fraction of firms have accurate information about the economy when they decide on their price: A λ share of the firms have forecasts based on the most recent data, while a $\lambda(1 - \lambda)$ share have information from one period before, and so on.¹⁵ This results in *past* expectations of *current* economic conditions affecting inflation today. Changing economic conditions therefore allows for persistence in inflation by not immediately materializing into changed pricing behavior, consistent with the persistence in inflation observed in the data. That means the *control gap*, the time that passes before a monetary policy action takes effect, is also accounted for by the model.

¹⁵The shares of agents who last updated their information in each period from now to infinitely many periods back sums to one: $\lambda + \lambda(1 - \lambda) + \lambda(1 - \lambda)^2 + \dots = \lambda \sum_{i=0}^{\infty} (1 - \lambda)^i = \lambda \frac{1}{1 - (1 - \lambda)} = 1$.

Mankiw and Reis (2001) show impulse responses to a reduction in nominal GDP, when the model features sticky information. Their results are given in figure 1. In a model with rational expectations and sticky prices, inflation would display a jump similar to the shock in GDP, with a gradual decay towards the stationary state. The sticky information model captures a feature of the data, which is that inflation only slowly responds to the changed circumstances, and the shock has effects on inflation for an extended amount of time.

Figure 1: Impulse response function with sticky information, sticky prices and backward-looking expectations. A shock of -10 percent to aggregate demand is simulated at time 0. Source: Mankiw & Reis (2001)



The crucial difference between the models that underlie the impulse response functions in figure 1 is that expectations in the sticky information model are formed rationally, with the caveat that not all agents form expectations rationally all the time. In the sticky price-model, expectations form rationally, i.e. agents know the true model. In the model with backward-looking expectations, the expected inflation rate next period is simply the inflation rate last period. The inertia in inflation expectations in a sticky information model, i.e. the fact that expectations do not instantaneously respond to economic shocks, makes inflation show similar persistence as in a model with adaptive, backward-looking expectations, which is also encountered in the data. With adaptive expectations however, the negative demand shock is followed by a boom in output after recovery from the initial shock, because inflation expectations are propelled by the deviation of output from steady state, like in the Philips curve in equation (2), and there is nothing anchoring inflation to the steady state. Rational expectations, however weakly present in the sticky information-model, provides an anchor that rules out such unrealistic fluctuations. This should make the model of sticky information

more palatable for skeptics of New Keynesianism who do not believe in the quick recovery that a New Keynesian model displays, although the requirement of micro-foundations would perhaps call for a properly founded reason for why businesses use outdated information for setting prices.

A reasonable story about such information dispersion, giving the sort of micro-foundations needed, is proposed by Carroll (2003), who constructs a model where the agents in the economy update their expectations based on information from the news media, who in turn base their stories on rational forecasts from professional forecasters. Not everyone pays attention to all macroeconomic news; any particular news story is absorbed by an individual with a certain probability. The time it takes for the entire public to have learned that macroeconomic circumstances have changed could therefore be substantial. Carroll (2003) suggests this type of model, which is dubbed *staggered information*, to explain expectations formation in a macro model with micro-foundations, similar to the role of Calvo-pricing in a sticky-price model.¹⁶

The proposition that agents base their expectations on information gathered from reliable sources is intuitively reasonable, and it is further backed up by a survey experiment in Armantier et al. (2012). There, respondents are asked to give their forecast of future inflation before and after they are provided with information about either past inflation or professional forecasters' predictions. They find that while a substantial fraction of respondents are well-informed on past inflation or professional forecasts, as many as 37.5 percent predict that inflation will be 5 percent or more. The average *perception gap* is therefore large. When provided with accurate information, the respondents revise their forecasts, supporting a model of expectation formation that is based on information gathering from the news. Armantier et al. (2012) are optimistic about increasing the effort in informing the public, in order to better manage expectations. A combination of different information-processing rules and heterogeneous information sets is suggested for modeling purposes. The respondents are provided information that is widely available, so their evidence does not support a theory of fully rational expectations. What Armantier et al. (2012) also uncover is that there are also wide disparities between demographic groups in their expectations of inflation; heterogeneity in expectations is greater among women, ethnic minorities and less educated agents. The same groups are also slower to update their expectations and have higher

¹⁶The model in (Carroll, 2003) is juxtaposed to the expectations data found in the Michigan Survey of Households. Based on the regression results, the pure sticky expectations forecasting process is preferred to a backward-looking process, even when combined.

inflation expectations (Madeira & Zafar, 2012).

The apparent heterogeneities in survey respondents' expectations pose a challenge for modeling. Branch (2007, 2004) solves this by letting agents switch between different prediction rules. He presupposes that the agents are uncertain which model is appropriate to forecast inflation, and allows them to change their minds. The different predictors that are available are (i) a VAR predictor, i.e. a full information forecast in the sticky information framework,¹⁷ (ii) a univariate adaptive expectations predictor that is backward looking, and (iii) a naive predictor taking last period's inflation as the expectation. Instead of letting heterogeneities be explained by stochastic processes, as in Mankiw and Reis (2001), the agents choose what information to disregard by the choice of predictor, and they do this purposefully, by evaluating which predictor yields highest benefit, i.e. by showing the lowest mean squared prediction error in the prior period. Estimation is costly, affecting the choice of method, which also provides an explanation for why the observed distributions of predictors used by different respondents vary over time. The cost is assumed to be higher the more often information is updated. The VAR contains 12 lags of inflation, output and interest rates on treasury bills, which makes the VAR fit the data closely. Empirical tests (Branch, 2007) show that all horizons of the VAR-predictor is used by some proportion of respondents, proportions varying over time. As a result, the heterogeneity of expectations formation is said to be dynamic. A static, geometric distribution of information updating, like in Mankiw and Reis (2001), is rejected. In Branch (2004), it is shown that when a naive predictor and an univariate adaptive expectations predictor is available, they will also be chosen by a share of the agents, over the more rational VAR-predictor.

In a similar vein, Akerlof et al. (1996) argue that workers only inform themselves about the inflation rate when it is too costly to ignore. High inflation and more news coverage has coincided, consistent with Carroll (2003) in that forecasts are more rational during times when inflation gets broad news coverage. This makes the cost of gathering information lower, while the cost of neglecting new information gets higher, all in all supporting dynamic heterogeneities in inflation expectations. This might be part of the answer to why it is easier to end episodes of high inflation than moderate ones, recalling the argument of Sargent (1982), as the public get intensely preoccupied with the inflation rate, and the probability of updating gets close to one.

¹⁷The VAR-predictor comes in four editions, which vary in how often information is updated, from every period to every twelfth period (3 periods and 9 periods in between).

Staggered information could be complimented by an element of *learning*, whereby agents estimate their model of the economy based on recent information about economic conditions. Models that incorporate learning allow for the possibility that inflation expectations can veer away from the central bank's target and become unanchored. This could happen if the central bank decides to pursue other goals than stable inflation, subscribing to a policy that is not optimal for inflation targeting. Agents then incorporate the central bank's behavior into their models, with the effect of a credibility loss if agents believe the central bank will be less aggressive in achieving stable inflation. Of course, learning would lead to re-anchoring of inflation expectations if the central bank is insistent in its efforts to stabilize inflation on target, which can be used to the central bank's advantage. One mechanism that emulates learning is that agents envisage a reduced form model of the economy, which they continuously revise in light of new developments. Orphanides and Williams (2005) argue that the Great Inflation of the 1970s in the US was caused by an underestimation of the natural rate of unemployment, making monetary policy more expansionary than what was ideal and, as a result, inflation skyrocketed. The increase in inflation was reinforced by expectations adapting to the new circumstances; the private agents in the economy reestimated their model of the economy with the most recent information. In the Orphanides and Williams (2005) model, the monetary authority uses private agents' expectations as inflation forecast. Since expectations are formed with up-to-date information, based on an outdated economic model, the inflation dynamics are similar to the models with backward-looking expectations, i.e. with inflation persistence. However, the Orphanides and Williams (2005) model is not a backward-looking model as such. The agents form expectations *boundedly rational*, limited to their most recent experiences. Learning agents are mostly wrong about inflation, creating inefficiencies, because they have limited information. This ascribes an important role for central banks in refinement of *communication* to improve the information set of agents. More informed agents would bring the dynamics of the model closer to those seen with rational agents. As Orphanides and Williams (2005) show, the presence of learning in inflation expectations highlights the role of credibility in the central bank policy tool-box. If central banks can point to a history of aggressively fighting inflation, agents will expect strong reactions to deviations from target in the future.

The way that sticky information models suggest information disperses throughout the economy implies that central banks' communication efforts are more effective if communication is targeted towards certain groups that act as *opinion leaders* relative to the rest of

the public. It seems reasonable that financial market experts and labor organizations are more attentive to central bank communication than e.g. households, which suggests that the experts' expectations are particularly amenable to expectations management efforts. Ullrich (2008) finds that aggregate inflation expectations among such experts in Europe are significantly influenced by ECB communication. Her study relies on the theoretical model by Svensson (2003) for why communication affects expectations, which posits that part of the gap between realized and expected inflation can be explained by the public not understanding the inflation expectations of the central bank due to not possessing the same information. In the study, a *wording indicator*, categorizing specific hawkish or dovish terms used in ECB statements, is used to show that the tone of ECB communication can partly explain changes in inflation expectations in the ZEW survey.¹⁸ A similar result was found by Jansen and De Haan (2007), who look at high frequency data, with focus on the difference between the interest rate on a non-inflation-adjusted bond and an inflation-adjusted bond. The authors find that central bank signals of a tightening of monetary policy had a significant effect on inflation expectations, but only in a period when macroeconomic indicators suggested a shift in ECB's policy stance would come, with tightening becoming increasingly likely during autumn 2005. They further find that the effect is only apparent at the start of a monetary policy tightening phase. Communication seemingly has the most effect when it is accompanied by actual policy changes. Words have to be followed up by action to be credible.¹⁹

Fracasso et al. (2003) use survey data to see if the message in central bank inflation reports reach different groups equally. The content of an inflation report is judged differently on several measures, like credibility and completeness of information. Fracasso et al. (2003) show that the more perceptions of the reports differ, the larger are the interest rate surprises.²⁰

In the literature, many suggestions to make inflation expectations act more realistically in economic models have surfaced over the years. In this thesis I only touch upon some of them, namely (i) models where sticky information prevents inflation from changing instantaneously, (ii) models where agents choose between different forecasting rules, and (iii)

¹⁸The ZEW survey is a survey of economic sentiment among 350 financial experts about the development in Germany, the Euro-zone, Japan, Great Britain and the US. Its website is <http://www.zew.de/en/publikationen/Konjunkturerwartungen/Konjunkturerwartungen.php3>.

¹⁹I discuss this theme further in section 5.

²⁰An interest rate surprise is defined as the difference in a market interest rate before and after announcement of a change in the policy rate. If the policy interest rate change was anticipated, there should be no change in market interest rates at the moment it was anticipated, everything else equal.

models where information is completely available, but agents only re-estimate periodically. These three proposals all approach the challenge of understanding inflation expectations *top-down*. They acknowledge a macroeconomic phenomena like the persistence of inflation, or the historical stagflation, and develop a story of expectations formation that is reasonably realistic and squares with the observed phenomena. The *bottom-up*-approach, on the other hand, is to measure inflation expectations empirically, and then model their behavior based on the observed data. Controlled experiments can further increase our understanding of why expectations develop the way they do. As already witnessed, survey data can be used to support theories that aim at explaining aggregate inflation phenomena. The next section provides an overview of how to measure inflation expectations empirically.

5 Measuring inflation expectations empirically

Even though inflation expectations are not directly observable, several methods exist for extracting them from other data sources. In this section, I will first present two common measures of inflation expectations, one based on financial market products, the other survey based, together with a run-down of methodological challenges pertaining to the latter.

5.1 Financial market-based inflation expectations

In several countries, there exist financial market products that make it possible to get an estimate of inflation expectations. These inflation expectations measures are in general arrived at by deconstructing the yield of financial instruments specifically designed to protect against inflation. One such instrument is *Treasury Inflation Protection Securities* (TIPS), issued by the US government. The principal of the TIPS is adjusted along with CPI-inflation, to make the *real* value of the principal stay constant. As non-adjusted government bonds expose the investors to the risk of inflation eroding the value of their investment, they demand a premium on the return to be willing to hold regular bonds, equal to the expected gain the TIPS-holders enjoy from their investment being adjusted for inflation, i.e. the expected inflation rate. Hence, expected inflation can be calculated by taking the difference between return on regular treasury bills and the return on the TIPS. Moreover, not only governments offer the added security of adjusting for inflation. A market for *inflation swaps* has also arisen in many countries. Companies and investors wanting to protect themselves against inflation can pay a fixed rate to a securities provider, and get paid the actual inflation

rate in return. The fixed rate is called the *break-even rate*, as the market price for the swap will be expected inflation. If inflation turns out to be what expected inflation was, the buyer of the swap breaks even on his investment. Markets for inflation swaps exist in Great Britain, Japan, the Euro area, and in the US. Norway has to date no market for inflation swaps, nor does the Norwegian government issue inflation-indexed bonds. As a result, Norway does not have a market-based measure of inflation expectations.

5.2 Survey measures of inflation expectations

Surveys are an important source of information for measuring inflation expectations, as one may potentially get a direct measure of expectations instead of having to derive them from spreads between financial market instruments. They are mainly performed by asking a large number of respondents standardized questions about their expectations of one or more variables, repeated at fixed intervals. As with other empirical methods, the aim of a survey investigation is to obtain a random sample of the target population in order to generalize the findings in the sample to the whole population. While surveys can be more qualitative in its questioning and have a probing, open-ended character, purely quantitative versions have been dominant in the economics literature. Inflation expectations surveys fall in a middling category, as it is hard to be certain if the interviewer and the interviewee interpret the questions the same way, and the sought-after answers are not objective facts. The challenge of how to operationalize the variables of interest into questions suitable for a questionnaire, and whether the answers have validity as actual expectations, has been shown considerable interest.

One interpretation of validity is whether the survey data can actually help forecast future inflation. The predictive power of expectations measured by surveys has been investigated by Mehra (2002), who considers inflation expectations and realized inflation to be cointegrated, moving together in the long run. In the short run, serially correlated forecast errors might make the variables drift apart. The fact that inflation and inflation expectations move together means that the development of expectations could give clues as to how actual inflation will develop. Tests for Granger-causality reveal that the survey forecasts have a forward-looking component with some predictive power for inflation.²¹ The tests of whether

²¹Granger causality entails that lagged values of one value “cause” present values of another variable. Granger (1980) required that past values of X have unique information about the future values of Y for X to cause Y . The usefulness of this concept lies in that it variables that Granger-cause another variable can be used to forecast the caused variable.

the forecasts are unbiased give mixed results, varying across surveys and time periods.

In the literature, the most widely used survey is the University of Michigan’s Survey Research Center’s survey of Consumers, commonly referred to as the Michigan Survey. It is based on a random selection of 500 American households, and is carried out monthly.²² The sample is *rotating*, i.e. about 60 percent of the respondents from one round is retained in the next, while the rest is replaced. The respondents are asked about their estimate for a price increase of the “*things you buy*” (Curtin, 1996).

Table 1: Inflation expectations surveys

Name (link)	Frequency	Origin	Description
University of Michigan Consumer Survey (http://www.sca.isr.umich.edu/)	Monthly	1959	Rotating sample. Targets households in the US. Highest Forecast Horizon (HFH) 5 years
The Survey of Professional Forecasters (https://www.philadelphiafed.org/research-and-data/)	Quarterly	1981	Avg. sample size 45. Targets Professional forecasters in the US. HFH 10 years
The Livingston Survey (https://www.philadelphiafed.org/research-and-data/)	semi-annually	1946	Informal survey. Targets Economists in academia, Finance and government. HFH 1 year
The ZEW Indicator of Economic Sentiment (http://www.zew.de/en/publikationen/Konjunkturerwartungen/Konjunkturerwartungen.php3)	Monthly	1991	Qualitative survey. Most respondents based in Germany. Targets professional forecasters in Finance. HFH 6 months
The European Commission Consumer Survey (http://ec.europa.eu/economy_finance/db_indicators/surveys/index_en.htm)	Monthly	1985	Qualitative survey. Representative sample from each EU country. Targets Households in Europe. HFH 1 year
Consensus Forecasts (http://www.consensuseconomics.com/download/G7_Economic_Forecasts.htm)	Monthly/ Quarterly/ /semiannually	1989	Varying sample size, forecasters from industrial countries. Targets Professional forecasters. HFH 10 years. (semiannually)
BoE NOP Inflation Attitudes Survey (http://www.bankofengland.co.uk/publications/Pages/other/nop.aspx)	Quarterly	2002	Also asked about support for and understanding of monetary policy. Targets Households. HFH 5 years
Norges Bank Forventningsundersøkelse (http://www.norges-bank.no/Publisert/Publikasjoner/Forventningsundersokelse/)	Quarterly	2002	Households asked about forecast of general level of prices. Targets households, firms, forecasters. HFH 5 years

There are several surveys that include inflation expectations in Norway. Noteworthy

²²Between 1959 and 1977, the survey was carried out quarterly.

examples include one that Norges Bank directs at households, professional forecasters and participants in centralized wage bargaining. The survey is performed quarterly, and dates back to the first quarter of 2002. The respondents are asked about, among other things, what their forecast of price and wage inflation over different horizons. Furthermore, the Norges Bank Regional Network of businesses also provide information about their expectations for future inflation indirectly, through their responses regarding their outlooks for employment, production and own prices.²³ Moreover, Statistics Norway conducts *Konjunkturbarometeret*, which has a similar purpose as Norges Bank’s regional network.²⁴ Table 1 lists the most important international surveys that include inflation expectations, and also the main survey for Norway.

There is some indication that the inflation expectations of businesses can be inferred from those of households, evidence for this is found by Coibion and Gorodnichenko (2013). As is elaborated in their discussion about expectation formation process, however, this should not be taken as evidence that there is a *causal* relationship from consumers’ expectations to those of businesses or professional forecasters. This is examined in Carroll (2003), where regression results from the sticky-information model show that the SPF forecast (survey targeting *professionals*, see table 1) Granger-causes the Michigan Survey forecast (survey targeting *households*), but not the other way around. Carroll (2003) also shows in a *horse-race regression* that the SPF has more predictive power for inflation than the Michigan survey does, when they are used as predictors separately.²⁵ When both are used as predictors at the same time, the Michigan survey loses its predictive power, while that of the SPF remains. Past inflation is used as a control, so the statistical significance of the SPF predictor satisfies the requirements of Granger-causality, i.e. that the survey contains unique information about the future development of inflation. The results in Carroll (2003) hence suggest that forecasters surveyed do not simply extrapolate past inflation into the future, as they would if their expectations were backward-looking. This, together with the fact that the SPF estimates have lower mean squared error than the Michigan survey, is taken as evidence that the responses in the SPF are more rational than those in the Michigan Survey.

By contrast, Mehra (2002) finds that the Michigan survey performs better than the SPF,

²³The Regional Network comprises 300 businesses, municipalities and organizations, and makes up a representative sample of the production side in Norway. The reports can be accessed at <http://www.norges-bank.no/Publisert/Publikasjoner/Regionalt-nettverk/>

²⁴Konjunkturbarometeret records production volumes in industry and mining. It can be accessed here <https://www.ssb.no/statistikbanken/SelectVarVal/Define.asp?MainTable=KBarTendenser&KortNavnWeb=kbar&PLang>

²⁵The Horse race regression is simply assessing which forecast has the most explanatory power when future inflation is regressed on them separately and together.

especially in the 80s and 90s, when the Michigan survey provides unbiased and efficient responses. In this period, the SPF respondents overestimated inflation, which gave biased, inefficient expectations. As these two examples show, there is disagreement about what should be considered the appropriate measure of inflation expectations in the economy. In the next section, I discuss some methodological issues pertaining to survey expectations which might explain some of the divergence between the inflation expectations measures.

5.3 Evaluating Survey data using experiments

The usefulness of survey measures of expectations to policy makers hinges on the validity of the responses to actual expectations and behavior. In the methodology literature, distinctions have been made between different validity concepts.

External validity refers to whether the results from an experiment can be generalized to the population at large. In the social sciences, one rarely finds simple, unambiguous relationships between variables, but to make experiments practicable, the phenomenon that is attempted reproduced must be simplified. This limits the degree to which experimental results can be expected to hold in the messier real world. In scientific studies, statistical methods, such as randomization, are used to control for possible confounding variables.

Internal validity concerns whether the conclusions drawn from experiments are warranted. In experiments, internal validity entails that the observed experimental effect can be attributed to the experimental stimulus (Campbell, 1957). Internal validity is therefore most relevant in experimental settings where a clear treatment is administered, and has less relevance for survey research, where no treatment is given.²⁶ There is often assumed to be a trade-off between external and internal validity, since simplified experiments are needed to identify causal effects (Jimenez-Buedo & Miller, 2010).

For surveys, however, the most relevant validity measure is *construct validity*, i.e. that the measurement device that is used actually measures what it is supposed to. Surveys rely on the researcher and the respondent understanding the questions in the same way, which is a major concern as much research aided by survey data concerns social constructs which give different associations to different people. Survey questions can have multiple interpretations if the researcher has not taken enough care. For example, questions about inflation expectations that ask for “the expected rise in the general price level” do not make clear which prices

²⁶Parallels to econometric estimation is the quality that estimators are unbiased and consistent, which ensures that the relationship between variables is measured accurately.

are in question, and how they should be weighted. Research using experiments to evaluate survey measures of inflation expectations have taken different approaches to investigate whether construct and internal validity is intact. Some of them I will broach below, namely the issue of (i) whether incentives are set up to assure accurate responses in surveys, (ii) that question wording ensures correspondence between the variable being measured and the interpretation of the respondents, (iii) how providing information as part of the surveying affects answers, (iv) how surveys can capture respondents' uncertainty about their answers, and (v) how answers depend on respondents' knowledge about how economic variables move in relation to each other. First, efforts have been made to clarify whether responses depend on incentives, since the effort involved in forming an expectation is significant. Most people do not think about inflation all the time, and might not have a well-formed expectation. There is a worry that in the absence of incentives, survey respondents will not expend the energy necessary to consider relevant information in order to form an inflation expectation. In one experiment conducted by Armantier et al. (2011), respondents are asked what their inflation expectations are, and subsequently asked to make an investment decision where the outcome depends on the realized inflation rate. In the second stage, participants have clear incentives to state their true expectation.²⁷ To a large degree, the respondent act like expected utility maximizers, responding to the incentives they are given. However, a close correspondence was found between the expectation stated when not given incentives, and that stated when giving the true expectation was incentivized, calming the worry that respondents won't give up their true expectations unless incentivized. The experiment also reveals that people pay attention to expected inflation when making investment, at least in the experimental setting. Investment decisions in the real world are based on more than the expected inflation rate, however, such as the discount rate and liquidity constraints, so it is difficult to say whether the agents' behavior in the experiment could be generalized.

Second, different *question wording* may give rise to different results, implying that the validity of surveys is sensitive to which questions are asked. The reason for this worry is that many survey measures, especially for households, report expectations that are systematically higher than actual inflation for prolonged periods of time. Surveys designed to measure inflation expectations among households intentionally use simplified language because the

²⁷The respondents are asked to choose between two lotteries, one that gives an amount in real terms with certainty, or an amount that relates negatively to the rate of inflation. By sequentially increasing the amount given with certainty, they find the respondents' *switching point*, where the expected value of the safe bet is equal to the expectation of the bet depending on the inflation rate. The expected value of the last bet depends on the probabilities the respondents assign to different rates of inflation.

subject is technical and not expected to be common knowledge. There is, however, reason to believe that simplification is counter-productive. de Bruin, Van der Klaauw, et al. (2010) show that asking about “the rate of inflation” indeed elicits lower responses than when asking for the expected rise in “prices in general”, closer to the actual CPI inflation. The terms are notionally the same, but may evoke different associations in the minds of the respondents who tend to focus more on the prices on goods and services that they typically buy when asked about “prices in general”, than when asked about “inflation”. The prices that have shown the most variability in recent times might be most salient to the respondents. The prediction dispersion is also lower when asking about inflation directly, rather than prices in general (de Bruin, Van der Klaauw, et al., 2010), which is another indication that simpler wording leads to more confusion. These findings are in line with other research in the field of survey design, where it has been shown that seemingly irrelevant wording differences give rise to different answers.²⁸

Third, the question of how respondents update their beliefs when provided with new information has attracted attention. Being provided with information affects the cost that respondents incur when they form an inflation expectation. In an experiment designed to see how respondents revise their expectations in response to new information, Armantier et al. (2012) include a control group that is not provided with the accurate information, but nonetheless asked for their inflation expectations. By comparing the answers of the group getting information with the control group, a clean estimate of the effect of providing information is provided.

Fourth, concern has been raised that survey measures of expectations and experiments do not capture individuals’ *uncertainty* about outcomes. The uncertainty in inflation expectations is a highly relevant metric for central banks, as it gives an indication of sentiment in the economy, and of the credibility of a monetary policy that aims for price stability, but it is not clear how to measure such uncertainty. Surveys asking for *point estimates* suffer from the disadvantage that only aggregate uncertainty can be extracted from the data. Using the dispersion of point estimates for inflation expectations has not been proven a good proxy for actual inflation uncertainty (de Bruin, Potter, et al., 2010). By instead asking for a *range* with assigned probabilities, individuals’ uncertainty can be directly measured. de Bruin

²⁸For example, people are more likely to endorse a proposal to “not allow” something than they are to “forbid it” (Holleman, 1999). Respondents are also more often willing to participate in a hypothetical medical experiment where the “success rate is 95 %”, than they are when “the risk of adverse effects is 5 %” (Linville et al., 1993).

et al. (2011) ask respondents for probability densities of inflation expectations, and they uncover heterogeneities between individuals that might be explained by financial responsibilities and literacy. Uncertainty also hit a high during the financial crisis among the more financially literate respondents, when many reported a wider range for their expectations. The results they find with this approach are consistent with inflation expectations from surveys asking only for a point estimate, suggesting that the added complexity of assigning probability to different outcomes is not overly daunting for the respondents.

Finally, a precondition for ascribing forecasting value to surveys targeting the wide population is that respondents have a reasonable understanding of how monetary policy works. Carvalho and Nechio (2014) look at whether the answers in the Michigan Survey are consistent with a Taylor rule for the monetary policy. Respondents who expect reduced unemployment and higher inflation should expect the policy rate to increase as well. The authors find that US households seem to understand monetary policy well, although results differ based on education and income. There also seems to be a better understanding of monetary policy in times when labor market conditions are weak, suggesting that heightened focus on economic issues in the news make households more aware of these principles. In a related study, Schmidt and Nautz (2010) examine whether experts' interest rate forecasts differ from realized policy rates because their expectations for inflation and output are off the mark, or if it is because they do not understand the central bank's decision. The authors utilize survey responses given by finance market experts about their expectations for various economic variables, and find that the experts consistently overestimate the ECB's response to increased inflation. However, since the ECB clarified its strategy in 2003, the experts' forecasts moved closer to actual policy. This suggests that clearer communication should be a prioritized goal for central banks, which goes hand in hand with building credibility in order to anchor inflation expectations on target. In the period after the financial crisis, inflation targeting central banks have been concerned with financial imbalances as part of their policy actions. If they are not successful in communicating that their main target, namely inflation, is not abandoned, it could hurt their credibility and reduce the efficacy of monetary policy instruments.

6 Empirical analysis of Norwegian survey data

In the remaining parts of this thesis, I evaluate some of the theoretical predictions about the behavior of Norwegian inflation expectations using data sets collected through surveys. I approach this evaluation in three ways. First, in this section, I conduct a survey with 1052 respondents to examine how much knowledge ordinary households possess about inflation, the processes that determine inflation, and their understanding of the link between inflation and monetary policy, in order to find out how reasonable the theoretical assumptions made about economic agents in the literature are. Second, in section 7, I investigate whether inflation expectations are accurate in their predictions or not. There, I especially rely on methods similar to those used in Mehra (2002),²⁹ and utilize the repeated survey that Norges Bank has developed to measure inflation expectations in Norway. Based on this data, I estimate a VAR containing inflation forecasts and realized inflation. By doing this, I am able uncover whether inflation forecasts contain information about future inflation to a greater extent than what is contained in past inflation, which would imply that agents are forward-looking, incorporating other information in their expectations formation than extrapolating past inflation. Third, in section 8, I try to uncover relationships between the expectations of different agent groups. In order to determine which groups to consider more reliable when using survey data to forecast inflation. I make use of the model developed by Carroll (2003)³⁰, which explicates this proposition and makes suggestions as to what kinds of relationships it is natural to search for.

6.1 How much do households know about inflation?

In order to get a better impression of Norwegian households' inflation expectations, I have designed a survey that was extended to a representative sample of Norwegian individuals. The questions concern the knowledge of the individuals about recent events that affects the Norwegian economy, and also a direct question about whether they seek out information about the economy deliberately. These questions are meant to shed light on the information-seeking habits of individuals, which would be extensive in the case that they are rational utility maximizers who seek to react optimally to any change in economic circumstances. The interviews were conducted by InFact on April 8th 2015, over telephone using automated

²⁹Mehra's (2002) approach and results are referenced in section 5.2

³⁰This model is described in section 4.

questions and pre-defined response alternatives.³¹ 1052 individuals over the age of 18 were interviewed in total, with a median age of 46. The questions are as follows: (i) How often do you follow news about the economy? (ii) Which of these five alternatives³² do you think will impact the Norwegian economy the most in 2015? (iii) CPI inflation in 2014 was 2 percent, do you think it will be, higher than, lower than, or the same as this in 2015? (iv) Can you explain what inflation is? (v) What happens to inflation when Norges bank reduces the interest rate?³³

The first two questions serve the dual purpose of getting a measure of how informed respondents are, and to prepare them for the questions that follow. The third question, concerning the respondents beliefs about future inflation, is styled similarly as in frequently used household surveys. The average inflation expectation measure that is taken out of these surveys hides the fact that individuals have widely differing beliefs about the economy. Seeing this question in relationship with the others in my survey, however, can provide insights into how much resources individuals invest in gathering the information on which they base their prediction, which in aggregate will determine the informational content of an inflation expectations average collected from surveys. The less individuals are informed about developments in the economy, the more uncertain their forecasts are likely to be, and the wider will be the distribution of the individual responses. If most economic decisions, which in aggregate determine inflation, are made using heuristics and rules-of-thumb, while individuals possess limited amounts of information about developments on a macro level, the ability of inflation expectation surveys of households to forecast inflation could be questioned.

Questions four and five delve further into the issue of whether people understand what inflation means, and the central bank's role in the mechanisms that determine what inflation will be. That people have an understanding of how the central bank intervenes with its policy tools to ensure stable economic growth is central to their understanding of how inflation develops in the face of economic shocks such as the oil price decline.

³¹Because the interviews are conducted by playing voice-recordings of the questions, I believe the chance that some respondents have answered the questions incorrectly on purpose is large. If this is the case, the resulting measurement error will decrease the accuracy of any conclusions I can draw from the data, but hopefully the errors are not systematical, meaning the data suggests misleading relationships.

³²1. The exchange rate. 2. The oil price. 3. Unemployment. 4. Wage growth. 5. Inflation.

³³The original formulation of the questions in Norwegian is contained in the Appendix.

6.2 Results

In the following, I will analyze the survey responses one question at a time, cross-referencing with other questions where relevant.

Question 1. Do you occasionally read news on economic events?

Table 2: How often do you read news on economic events?

Answers	No	Monthly or less	Weekly	Daily	Unsure	Total
Frequency	281	308	240	149	74	1052
Percent	26.6 %	29.2 %	22.8 %	14.1 %	7 %	100 %

As expected, how frequently people update themselves on economic events varies greatly. Depending on their interests and financial responsibilities, people feel that developments in the economy affects their life to a lesser or greater degree. About 65 percent percent of the respondents say they follow the news less than once per month, or never, see table 2. Although a majority of Norwegians pick up a newspaper every day, follow the news on the internet, radio or television (Statistics Norway, 2015), the news that concern economic events seemingly reach only a smaller audience. Considering that reports about the economy are mainly confined to niche newspapers and finance sections of the largest subscription newspapers, while local newspapers are what most readers pick up, this is not very surprising. Especially with the advent of the internet as a news source, media consumption has become increasingly selective, and consumers will not seek out information that is not in their interest. The share of respondents who say they follow news about economic events at all increases with age, up to 65 years, see table 3. While about the same share of respondents between 18-29 years and 30-44 years follow the economics news daily, the share doubles for the age group 45-64 years.

Table 3: Respondents to question 1 by age groups

		18-29 yrs	30-44 yrs	45-64 yrs	+65 yrs
Follow news at least monthly	Count	132	182	255	128
	% of age group	60.7%	66.3%	74.7%	58.7%
Follow news daily (included above)	Count	24	24	70	31
	% of age group	11.0 %	8.7 %	20.7 %	14.3 %

Acknowledging that not all households in the economy do not find it worthwhile to inform themselves about economic developments does not imply that agents are not at all rational in their decision making, as it is costly to acquire information that might only

be of marginal value in economic decision making processes, and information needed to make sound long-term decision does not require daily updating. The notion that aggregate outcomes in the economy will reflect that all agents in the economy are rational, however, is harder to uphold. Furthermore, if people are not particularly informed about the economy, it is a stretch to consider their average inflation expectations to be a good forecast of future inflation, as previously mentioned.

Question 2. Which of the following will have the largest effect on the Norwegian economy in 2015?

When asked which will be most important of the exchange rate, the oil price, unemployment, wage growth, or inflation, a large share of the respondents picked the oil price as the most important factor.

Table 4: Which of these alternatives do you think will affect Norway's economy the most in 2015?

Answers	Exch. rate	Oil price	Unemp.	Wage gr.	Inflation	Unsure	Total
Frequency	96	403	202	62	28	261	1052
Percent	9.1 %	38.3 %	19.2 %	5.9 %	2.7 %	24.8 %	100 %

The dramatic decline in the oil price is the event that have attracted the most attention in the news in the early part of 2015, prominently featuring in the ensuing discussion about what the consequences for the Norwegian economy in the short and long term will be, see table 4. That the share who are concerned that unemployment will be an important factor for the economy is large is surprising, given that unemployment is very low at the moment. Although unemployment has increased in some industries, it is not likely to become a major concern or affect a large part of the population. What will affect a large share of people, on the other hand, is lower wage growth than what has been the norm in previous years. The lower wage growth is likely to result from the diminished activity and demand in the economy, and will be felt at the aggregate level, but might not be dramatic enough for people to be worried about their personal economy. The low share that chose inflation or the exchange rate probably reflects that the present development of these variables has few adverse effects on the Norwegian economy, but it could be expected that some might have picked up that low inflation internationally has been problematized.

Question 3. Will the change in CPI be higher, lower or the same in 2015 compared to 2014?

Table 5: The growth in CPI was 2 % in 2014, do you think it will be higher, lower, or the same in 2015?

Answers	Higher	Lower	The same	Don't know	Total
Frequency	307	213	335	197	1052
Percent	29.2 %	20.2 %	31.9 %	18.8 %	100 %

This question concerns the respondents' inflation expectations for the year 2015, and is posed similarly to questions frequently used in household surveys. Because of the interview method used, the data is categorical, meaning numerical expectations could not be measured. Instead, the respondents were given information about what the CPI growth was in 2014 (2 %), and asked whether they thought inflation would be (i) lower than, (ii) higher than, or (iii) the same in 2015. My main interest in this section is to analyze how well informed individuals are about recent economic developments and what this means for the prospect of measuring inflation expectations using surveys targeting regular households. In the following, I will therefore evaluate the precision of the responses given in table 5, against other expectations measures and recent events that will influence monetary policy decisions and the business cycle. In July 2014, the oil price started a rapid decline from a stable, high level of over \$100 per barrel. Oil production makes up a significant portion of Norwegian exports, and although oil producers will still operate with a profit, and the public sector is insulated against the fall in tax revenue because of the channeling of oil revenue through Norway's *sovereign wealth fund*, the price decline is nevertheless expected to slow the Norwegian economy due to lower demand for oil related services, such as prospecting for oil fields and development of new production capacity. In December 2014, Norges Bank reacted to the oil price decline with cutting the policy interest rate with 25 basis points. The central bank has given strong signals that the policy rate will be cut further, but surprised markets in March 2015 by postponing the expected reduction from the already low level of 1.25 percent. Norges Bank's judgement was that the oil price decline had not yet manifested itself in dramatically weaker demand in the economy, and a rate cut was not justified. Norges Bank has not taken a future rate cut off the table however, if the current situation persists. The expected decrease in the policy interest rate speaks in favor of higher inflation in 2015 than in 2014. So does the depreciation of Norwegian Kroner against all major currencies, which means imported inflation should be higher. On the other hand, prospects of lower wage growth

and a lower level of activity than before should push inflation down. The effect of recent events on inflation for 2015 is therefore not entirely clear.

Inflation expectations over the next 12 months among economic experts, business executives and labor organizations, measured in the first quarter of 2015, are 2.3, 2.4, and 2.2 percent respectively.³⁴ These groups hence agree that inflation will be higher in 2015 than in 2014, but slightly below target. In the first quarter of 2014, they were 2.1, 2.3, and 2.2 percent respectively.

In my survey data, presented in table 5 respondents disagree whether inflation will be higher than (29.2 %), the same as (31.8 %), or lower than (20,2 %) it was in 2014. Opinions are relatively evenly spread over the two former, which consume about 60 percent of the sample, and which are most in line with the experts and business leaders asked in the Epinion survey.

Table 6: Cross-tabulation of inflation beliefs and reading news

		CPI-Inflation in 2014 was 2 %, what will it be in 2015?				
		Higher	Lower	The same	Unsure	Total
Do you occasion- ally fol- low news on the economy?	No	33.6 % (94)	11.8 % (33)	26.5 % (74)	28.2 % (79)	100 % (280)
	Monthly	30.4 % (94)	17.2 % (53)	34.7 % (107)	17.7 % (55)	100 % (308)
	Weekly	29.8 % (71)	26.4 % (63)	34.4 % (82)	9.5 % (23)	100 % (240)
	Daily	21.2 % (32)	36.4 % (54)	35.6 % (53)	6.8 % (10)	100 % (149)
	Unsure	21.8 % (16)	11.9 % (9)	24.9 % (18)	41.4 % (31)	100 % (74)
	Total	29.2 % (307)	20.2 % (212)	31.9 % (334)	18.8 % (198)	100 % (1052)

Table 6 shows the proportion of respondents with varying beliefs about the future path of inflation separated based on informedness. The likelihood that someone thinks inflation will be higher in 2015 than it was in 2014 seems to decrease the more informed that person is. Equivalently, the share of people who think inflation will be lower increases the more often they read news about the economy. Pearson's χ^2 rejects independence between informedness and inflation expectations with a high degree of significance ($\chi^2 = 105,91$).³⁵ The reason for this could be that less informed respondents confuse CPI inflation with the price level, which will be higher next year as long as inflation is positive. This could make more people answer that CPI inflation will be higher in 2015 than 2014 even though they might be of the opinion that the price level will increase with less than 2 percent.

³⁴From Forventningsundersøkelsen conducted by Epinion by Norges Bank: http://static.norges-bank.no/pages/102756/forventningsundersokelse_q1.2015.pdf?v=26022015100557

³⁵Pearson's χ^2 is a test used on categorical data to examine whether the differences in observed distribution when controlling for another variable is because of random variation or if it is systematical. The test statistic is $\chi^2 = \sum_i \frac{(O_i - E_i)^2}{E_i}$, where O_i is the observed frequency, while E_i is the expected frequency.

The feature that the most informed individuals are more likely to expect inflation to go down seems to go counter to the experts' beliefs about how recent events will affect inflation. It could be that the news about lower levels of activity in the Norwegian economy is what has caught people's attention, because the effects of a lower oil price on wage growth is what is most frequently reported in the news. The effect of the central bank's reaction to this development on inflation, on the other hand, is not so straightforward and obvious, and is not something people relate to personally as they do with wage growth. The next questions that I asked address this issue.

Question 4. Can you explain what inflation is?

The degree of knowledge about inflation dynamics might also explain part of people's uncertainty about what inflation will be in the future, found in the results from the last question discussed. This potential confusion might stem from a lacking understanding of the concept of inflation, the extent of which I want to measure with the current question. The respondents are asked to choose between three alternative definitions of inflation: price growth, price growth that is *higher than normal*, or the printing of money. Almost 40 percent of the respondents answer that they think inflation means *a higher price growth than normal*, whereas 35 percent chose the correct definition of inflation which is simply price growth, see table 7.³⁶

Table 7: Can you explain what inflation is?

Answers	Printing money	Price growth	Price g. above normal	Don't know	Total
Frequency	92	366	402	192	1053
Percent	8.7 %	34.7 %	38.2 %	18.3 %	100 %

Only about 9 percent answered "printing money" when asked about what inflation is, which implies respondents are able to distinguish between inflation and what causes it in special circumstances, such as during the most famous episodes of hyperinflation.

In table 8, respondents who choose different definitions of inflation are divided based on how often they follow news about the economy. The share of people who pick the correct definition of inflation increases with how often they read news about the economy. Pearson's χ^2 also here suggests that this variation is not due to chance ($\chi^2 = 116, 7$).

³⁶Technically, the correct definition of inflation is "sustained price growth", but in order to concentrate on the difference between just price growth and price growth higher than normal (hyperinflation), the alternatives were made more concise.

Table 8: Cross-tabulation of knowledge about inflation and reading news

		Can you explain what inflation means?				
		Printing money	Price growth	Price g. above norm	Don't know	Total
Do you occasionally fol- low news on the economy?	No	8.5 % (24)	27.2 % (76)	33.3 % (93)	31.0 % (87)	100 % (281)
	Monthly	8.4 % (26)	31.8 % (98)	42.5 % (131)	17.2 % (53)	100 % (308)
	Weekly	10.9 % (26)	38.4 % (92)	43.9 % (105)	6.8 % (16)	100 % (240)
	Daily	6.5 % (10)	58.6 % (88)	28.3 % (42)	6.7 % (10)	100 % (149)
	Unsure	8.3 % (6)	15.4 % (11)	40.5 % (30)	35.7 % (26)	100 % (74)
	Total	8.7 % (92)	34.7 % (366)	38.2 % (402)	18,3 % (193)	100 % (1052)

Among the most informed, respondents who follow news about the economy daily, 58.1 percent think inflation means the general increase in prices. There seems to be a divide between respondents who read news about the economy daily, and people who read news less often, as the share who answers correctly increases by quite a lot when going from one group to another. The mistaken belief that inflation refers only to periods where the price level increases more than normal could spring from the highly popularized photos of heaps of paper money during the hyperinflation of Germany after the First World War, or the more recent hyperinflation in Zimbabwe which reached its peak in 2008 at 231,000,000 percent (The Economist, 2013). Inflation which is on a level that doesn't distort economic decisions and gives agents reasonable predictability is what should be associated with 'low inflation.' Inflation targets of 2 - 2.5 percent fall within this definition. As opposed to hyperinflations, the less dramatic phenomenon of low inflation is something many people might not pay particularly close attention to. This is such a common oversight that a term has been coined for it, namely *money illusion*. The term refers to people's tendency to think of amounts of money in nominal terms, disregarding price changes that occur over time that change the purchasing power of money. However, people who suffer from money illusion might recognize the concept of inflation if they are reminded of it, such as in this survey, or if inflation is high. Alternatively, they might not understand it, which is understandable seeing as inflation is a rather technical term. Research has shown that people easily confuse economic concepts, for instance taking an increase in *labor supply* to mean that more unfilled jobs are available (Strandgaard & Andersen, 2015).

Question 5: What effect would a reduction in interest rates have on inflation?

Central banks with an inflation target mainly use one or more policy interest rates to influence inflation in the desired direction. Lowering the policy rate leads to lower market

interest rates, which makes it more attractive for consumers to spend money now rather than later, and for businesses to make investments, thereby increasing activity in the economy. In theory, this leads to higher inflation as businesses increase their prices in line with the higher demand, and workers increase their wage demands as unemployment is reduced. A reinforcing effect goes through the exchange rate in small, open countries like Norway, as investments shift out of the country and the Krone depreciates, making imports more expensive. A lower policy interest rate therefore corresponds to higher inflation. The responses to question 5 can be seen as a test of the respondents' understanding of monetary policy. The result indicates that the way monetary policy works is not properly understood by everyone, see table 9:

Table 9: If Norges Bank lowers the interest rate, what happens to inflation?

	Unchanged	Increases	Decreases	Don't know	Total
Frequency	93	366	214	379	1052
Percent	8.9 %	34.8 %	20.3 %	36 %	100 %

Only 34.8 percent of respondents answer correctly that inflation will go up if the policy rate is lowered.³⁷ A whole 36 percent of the respondents answer that they don't know what will happen, indicating that they do not feel knowledgeable enough about the subject to guess at what will happen. Even among respondents who read news about the economy daily, 42.3 % of the respondents get this question wrong, as can be seen in table 10 (Pearson's χ^2 is 99.27, indicating results are not random). The share that answers correctly does however increase with the frequency of following news on economic events. The share who answers that they are unsure shows a particularly large decrease.

Table 10: Cross-tabulation of monetary policy understanding and reading news

		If Norges Bank lowers the interest rate, what happens to inflation?				
		Unchanged	Increases	Decreases	Unsure	Total
Do you occasionally fol- low news on the economy?	No	9.2 % (26)	24.3 % (68)	17.2 % (48)	49.3 % (138)	100 % (281)
	Monthly	8.8 % (27)	34.1 % (105)	24.2 % (75)	32.9 % (101)	100 % (308)
	Weekly	10.0 % (24)	39.4 % (95)	22.9 % (55)	27.7 % (67)	100 % (240)
	Daily	7.1 % (11)	57.7 % (86)	18.5 % (28)	16.7 % (25)	100 % (149)
	Unsure	7.5 % (6)	16.5 % (12)	11.7 % (9)	64.3 % (48)	100 % (74)
Total		8.9 % (93)	34.8 % (366)	20.3 % (214)	36.0 % (379)	100 % (1052)

In sum, the responses gathered through this survey suggest that a large share of indi-

³⁷Which answer is correct does depend on whether the question is interpreted as what would happen according to economic theory, or what happens in reality. In the latter case, there might not be a clear-cut answer. People's recent experience with low inflation in Norway and internationally, while interest rates are also low, provides experiences which can go counter to what economic theory predicts.

viduals are not particularly well informed about developments in the economy, based on the frequency with which they update themselves on news about the economy. The mechanisms determining inflation also seem to be not very well understood. If this is true of the population as a whole, and not just a feature of my sample, it does not bode well for the prospects of extracting useful inflation forecasts from households. In the next section, I will look at exactly this, namely how much information about future inflation can be drawn out of households' inflation expectations, if any. I will also examine whether the inflation expectations of households are rational, and if there are other groups that are better at forecasting inflation.

7 How rational are survey expectations?

In the literature, good forecasts based on expectations require that expectations are rational, i.e. that all relevant available information about the economy is incorporated in the forecast. The degree of rationality in observed data is a question of how well agents can actually predict future inflation. Rational expectations would manifest themselves in an observable relationship between expectations and actual inflation. If expectations are rational, predictions should not make systematic errors about the future development in inflation. A finding that observed inflation expectations are good predictors of realized inflation would make them a valuable tool for policymakers and other agents in the economy who take interest in what the inflation rate will be.

In this section, I evaluate the survey data on inflation expectations from Norway, using various criteria, to examine their ability to predict inflation. I start with some descriptive evidence, and then go on to more technical evaluators.

7.1 Data and stylized facts

The inflation expectations data for Norway is mainly contained in a quarterly survey designed by Norges bank, and conducted by Epinion AS to gauge the expectations of different groups in the Norwegian economy.³⁸ A sample of households, economists, business executives, and labor organizations are asked separately about their inflation expectations at different horizons. I will pay special attention to the expectations of households and

³⁸Norges Banks Forventningsundersøkelse – <http://www.norges-bank.no/Publisert/Publikasjoner/Forventningsundersokelse/>. The survey was earlier conducted by Opinion Perduco/Opinion (2009-2014), and TNS Gallup (2002-2008).

economists, as the theory described give these a central role. In the survey, households are first asked a couple of questions about how they think prices on goods and services have developed in the *past* 12 months. Next, they are asked by how many percent they think prices will change in the *next* 12 months. Households are further asked what they think the increase in prices will be in “two to three years”, which gives information on longer horizon expectations. Economists, business executives and labor organizations are asked about their forecast of the yearly inflation rate one, two, and five years ahead.

In this section, I utilize various measures of inflation to evaluate the rationality of inflation expectations. Different measures of inflation include different price elements, some of which are more volatile and depend more on market conditions in the world economy than others. The most commonly used inflation measure is (i) the *Consumer Price Index* (CPI), which measures the price of a weighted bundle of goods, usually indexed to a reference year for the country in question. Removing specific elements give measures of inflation that are more stable over time. (ii) CPI-ATE is based on the CPI, but excludes energy prices and changes in product taxes. (iii) CPI-ATE-IMP covers the prices on imported goods and services, while (iv) CPI-ATE-I is the component of CPI-ATE that comes from domestically produced goods and services. Another, more general way of decomposing the consumer price index is to separate it into one index containing prices that change more frequently than the median, and another index containing the prices that change less frequently than the median (Erlandsen, 2014), the latter which I will call (v) CPI STICKY. I will evaluate the rationality of survey expectations against all these inflation measures.

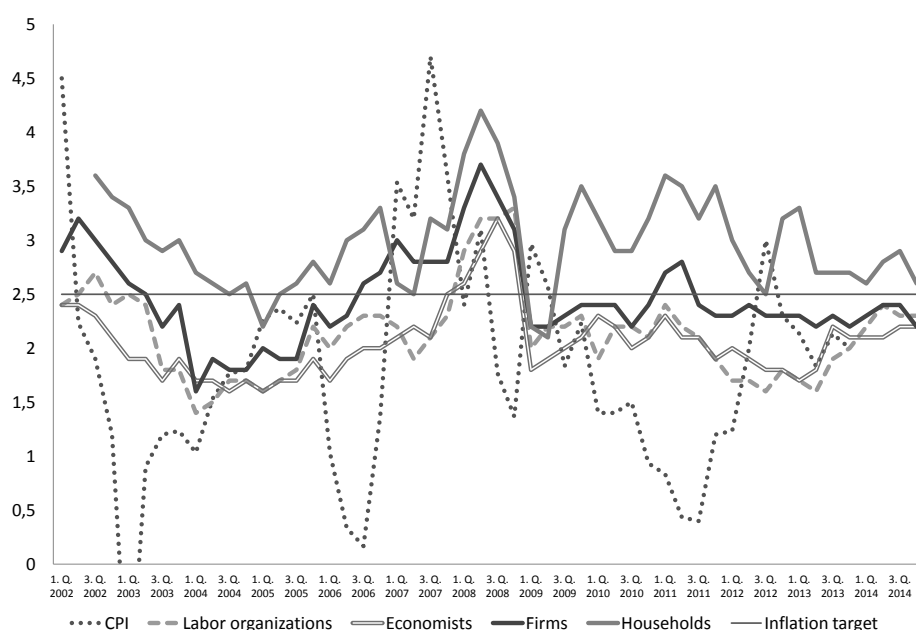
Survey response data was accessed from opinion.no on March 4th 2015. (i), (ii) and (iii) was accessed from SSB on March 11th 2015. These series are monthly 12-month growth. To get quarterly numbers I averaged the values for the months of each quarter. (iv) was collected from the data attachments of Norges Bank’s Monetary Policy Report. (v) was generously provided by Solveig Erlandsen. All price index data are measured as 12-month change.³⁹

As can be seen from figure 2, households’ inflation expectations for inflation one year ahead are generally high throughout the sample, mostly lying above realized inflation and the inflation target. Average households expectations for the twelve years in the sample is 3 percent, whereas the average actual inflation in the CPI-index was 1.83 percent. Economists

³⁹The CPI-ATE-I time series was gathered in this way: From PP 4/14: 10/2014-1/2010, from PP 2/10: 12/2009-1/2007, from PP 2/07: 12/2006-1/2002.

in finance and academia have on average been closer in their expectations, with 2.05 percent. During the same period, Norges Bank has operated with an inflation target of 2.5 percent. Expectations of labor organizations and firms are also higher than actual inflation at most instances, mostly hugging the inflation target at 2.5 percent, even though inflation was lower than that during most of the period. Economists, businesses and labor organizations seem to have been adjusting their expectations along with inflation somewhat. Whether this is an adaptation of expectations to past inflation or accurate forecasts remain to be seen.

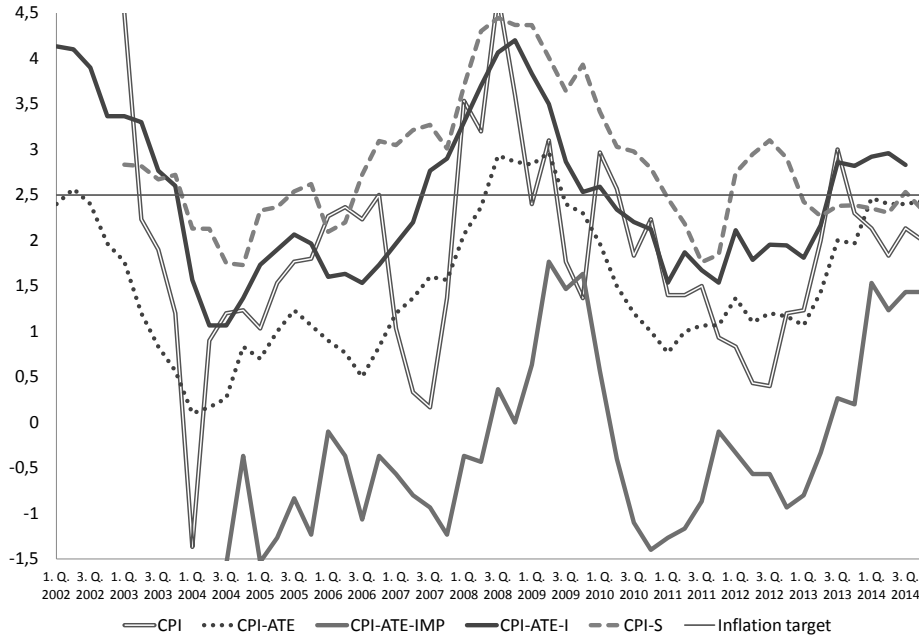
Figure 2: 1 year ahead inflation expectations and CPI. CPI values are $t+4$, so that at every point it shows what inflation will be in the next 12 months, to be comparable with expectations



There are several possible explanations for this gap between households' stated expectations and the realized inflation rate. First, it seems likely that what comes to the respondents' minds when asked about price changes is not the general price change measured by the CPI, but specific prices that they are familiar with. If these prices have had higher growth than the growth in CPI, it would explain part of the discrepancy between expectations and CPI inflation. Figure 3 shows how the different measures of inflation vary from each other. One thing that sticks out is how low CPI-ATE IMP was during the sample period compared with the other series. Imported inflation makes up one third of CPI, affecting the level of this variable considerably. Food and housing services typically produced domestically and elements of the higher CPI-ATE-I-index, and takes up a large share of households' budget. These prices might be more familiar to regular households. Second, it might be that house-

holds do not form their expectations adaptively, by looking at past realized inflation rates, but inform themselves by consulting the opinions of experts, who as portrayed by the figure, have also tended to expect inflation to be higher than what it actually turned out to be. This fits with the theory of sticky information (see section 3). A third possible explanation, which could be especially important for Norway where a big part of wage bargaining is conducted centrally, is that households derive their inflation expectations by looking at increases in the nominal wage level, which is a variable that households are perhaps more likely to pay attention to. In the years included in the sample, Norwegian households have seen considerable increases in their real incomes.

Figure 3: 12 month change in inflation – 5 different measures



Because of the evidence of persistence in inflation discussed in section 2, it is interesting to first model these series as *autoregressive processes*. The AR(1)-specification involves estimating a regression of the form $\pi_t^e = \rho\pi_{t-1}^e + \epsilon$, which captures the variable's dependence on its past. For the sample period that I look at, regressing households' inflation expectations as an AR(1)-process returns a lag coefficient of 0.98, which is very close to a unit root. If ρ turns out to be equal to one, can be written as $\delta\pi_t^e = \epsilon$, meaning the time series is a *Random walk*-process where the disturbances accumulate without dying out, resulting in the variable not converging to an equilibrium in the long run some empirical research suggests that these variables might be better characterized as *random walks* (Ball, Cecchetti, & Gordon, 1990, Barsky, 1987), which has consequences for inference using these variables.

Non-stationarity, or *integration*, renders standard inference methods invalid. Granger and Newbold (1974) showed that OLS regression on variables that are integrated can lead to significant relationships even though there are none in reality. It can however be difficult to distinguish between unit root processes and processes that are highly persistent (Ball et al., 1990), which inflation expectations clearly is an example of. In the presence of structural breaks in the data, it might be the case that a highly persistent process is non-stationary at some intervals, but otherwise stationary. The coefficient is estimated to be close to one, and the data does not allow me to reject the hypothesis that the ρ -coefficient is equal to one (p-value of 0.41). I perform tests for stationarity later, in section 8.1, where I find that households' and experts' expectations are likely I(1). Further, testing for autocorrelation in the residuals from the regression of the AR(1)-formulations shows that serial correlation has been accounted for by the first order lag. The residuals seem to follow a *white noise* process.

7.2 Tests for unbiasedness of survey expectations

To analyze whether expectations can be considered rational, one can estimate a regression equation like the following,

$$\pi_t = \alpha + \beta \pi_{t|t-1}^f + \epsilon_t \quad (3)$$

where π_t is the actual inflation rate, and π_t^f is the forecast of inflation in period t, made in period t-1. If expectations are able to forecast inflation accurately, one would expect that the constant in this equation is zero, and the coefficient on the expectation equal to one. Any deviation between expectations and the actual inflation rate would be random, and captured by the error term ϵ_t , which is assumed to have zero mean and constant variance (Grant & Thomas, 1999)

When estimating equation 3 by OLS, the usual null-hypothesis concerning the constant implies that expectations are not systematically above or below actual inflation. If expectations were rational, non-rejection is what we should expect. Regarding the estimate of β , non-rejection of a hypothesis that it is equal to one is consistent with rationality. These hypotheses can be considered jointly using a F-test. If non-rejection is the outcome of the test, it could rely on at least two explanations. Either the null hypothesis is correct, that is, the inflation expectation is unbiased, or there is not enough power in the data to reject a false null hypothesis. If the squared errors from the unrestricted regression on the available

sample are large, the test result could conclude that imposing the unbiasedness-restriction is an equally good fit within the limits that statistical uncertainty impose. Statistics such as the R^2 provides information about whether the latter case is the most likely. If the tests indicate rejection, however, we can be fairly certain that the expectations measures are biased.

Table 11 presents some error statistics from regression of equation 3, as well as OLS regression of inflation on past inflation 12 months prior, which would be the most recent inflation report at the time when the respective groups surveyed made their inflation forecast. What is reported is the *Root Mean Squared Error*, i.e. the mean squared error from predicted values of the dependent variable in the regressions. The numbers in italics are the ratio of these two statistics, which indicates whether the forecasters or the naive forecast are more accurate. A ratio below one means the survey measures of inflation contain more information about future inflation than what extrapolating past inflation does. The economists' forecast

Table 11: Forecasting Accuracy of Survey Measures of Expected Inflation

	CPI	CPI-ATE	CPI-ATE-IMP	CPI-ATE-I	CPI-S
Households	1.01 <i>1.09</i>	0.75 <i>1.04</i>	1.04 <i>1.09</i>	0.74 <i>0.99</i>	0.68 <i>1.03</i>
Economists	1.06 <i>1.15</i>	0.65 <i>0.91</i>	0.93 <i>0.97</i>	0.67 <i>0.90</i>	0.58 <i>0.86</i>
Labor org.	1.08 <i>1.02</i>	0.72 <i>1.00</i>	1.02 <i>1.06</i>	0.72 <i>0.97</i>	0.6 <i>0.89</i>
Business exec.	1.06 <i>1.14</i>	0.67 <i>0.92</i>	0.97 <i>1.01</i>	0.61 <i>0.82</i>	0.56 <i>0.83</i>
Naive Forecast	0.93	0.72	0.96	0.74	0.67

Numbers reported are Root Mean Square Error from regression of equation 3. The Naive Forecast is inflation 12 months prior, i.e. an AR(1)-process where the autoregressive component is lagged four quarters. Numbers in italics are the ratio of RMSE in each regression to RMSE of the naive forecast.

is more accurate for most of the inflation measures than the naive forecast, which is a result that will reappear later, when discussing the main results from these regressions. What is also a recurring finding is that the forecasters are generally better able at forecasting the inflation measure that is composed of domestically produced goods (CPI-ATE-I).

In table 12 are the main results from OLS regression on equation (3), using different

Table 12: Test of unbiasedness

Households	CPI	CPI-ATE	CPI-ATE-IMP	CPI-ATE-I	CPI-S
β	-.472 (-1.16)	.309 (0.87)	.385 (0.79)	.397 (1.44)	.453* (1.68)
α	3.188 (2.84)	.524 (0.51)	-1.500 (-1.10)	1.125 (1.37)	1.454 (1.81)
Bias-test	29.31***	58.81***	192.18***	14.90***	4.55
Centered R^2	0.04	0.03	0.02	0.05	0.08
Experts	CPI	CPI-ATE	CPI-ATE-IMP	CPI-ATE-I	CPI-S
β	.573 (1.29)	1.082*** (3.49)	1.430*** (3.65)	1.116*** (3.01)	1.1678*** (4.82)
α	.661 (0.72)	-.764 (-1.15)	-3.253 (-3.67)	.0769 (0.10)	.4230 (0.90)
Bias-test	1.70	12.85***	121.79***	3.72	31.09***
Centered R^2	0.03	0.24	0.22	0.24	0.32
Labor org.	CPI	CPI-ATE	CPI-ATE-IMP	CPI-ATE-I	CPI-S
β	-.0146 (-0.05)	.484 (1.30)	.660 (1.10)	.6345*** (2.47)	.8664*** (5.48)
α	-2.020 (-3.72)	.427 (0.55)	-1.729 (-1.40)	1.018 (1.95)	.9813 (3.34)
Bias-test	10.84***	12.78***	98.88***	4.33	34.89***
Centered R^2	0.00	0.08	0.07	0.12	0.28
Firms	CPI	CPI-ATE	CPI-ATE-IMP	CPI-ATE-I	CPI-S
β	.524 (1.52)	.8019*** (2.71)	.9917*** (2.66)	1.074*** (5.04)	.982*** (4.19)
α	.542 (0.69)	-.527 (-0.77)	-2.757 (-3.03)	-.2956 (-0.59)	.389 (0.74)
Bias-test	8.41**	37.36***	144.18***	0.98	8.78**
Centered R^2	0.04	0.21	0.15	0.368	0.36

t-values in parantheses. Stars indicate significance level, *** significant at 1% ** significant at 5 % * significant at 10 %. The regressions are of the form $\pi_t = \alpha + \beta\pi_{t-1}^f + \epsilon_t$, and the Bias test displays the F-values from testing the joint hypothesis that $\alpha = 0, \beta = 1$

inflation measures and the different series from the survey. The point estimates from the individual regressions are shown, as well as a test of the hypothesis that the constant and the coefficient is jointly zero and one, respectively, against the alternative hypothesis that they are not. The level of confidence with which the null-hypothesis can be rejected is indicated.

Rejection of the joint hypothesis that expectations are unbiased is indeed the conclusion for most of the combinations of inflation measures and groups of forecasters. The households fare worst, with the hypothesis of no bias being rejected in all cases, except compared to the sticky part of the CPI. The movement in household inflation expectations seem to correlate little with that of actual inflation – in no case is the β -coefficient significantly different from zero on its own, and R^2 is very low. Because of the low correlation between expected and realized inflation, the point estimate of the constant almost takes on the average value of inflation over the sample. If the expectations and actual inflation moved together more strongly, however, I would expect a negative estimate on the constant by looking at the graphical representation of the series, where actual inflation lies well below expectations for all inflation measures.

The other groups that are surveyed (economists, labor organizations and business executives) fare just as badly as households in the test for unbiasedness, in most cases. These groups' expectations do however track inflation more closely, with point estimates of β closer to one, and individually significantly different from zero. The regressions on CPI is an exception, as this index, containing energy prices, is very volatile compared to the more stable expectations. Comparison with CPI is therefore not a good criterion to judge inflation expectations, which by definition take on too long a perspective to capture the sudden changes in CPI. CPI-ATE, which excludes oil and energy prices share more of the stable feature of expectations. Even more so does CPI-ATE-I, which is the price index on domestically produced goods and services. Table 12 suggests that the expectations measures are better able to forecast this index than others. The explained share of variation, measured by R^2 is large for this index relative to the others, and only for household expectations is the null of no bias rejected. The point estimates for β are very close to one for both economists and business executives. It is perhaps reasonable that the latter group is good at forecasting this measure of inflation, as businesses are exactly the ones who decide on the prices in this index, and have to monitor this landscape closely to assess competition and the appropriate price. This index is also highly relevant for labor organizations, whose bargaining position is to a large degree determined by the level of producer prices, through the ability of firms to pay a higher

nominal wage. The rightmost column regresses inflation expectations on goods and services in the CPI whose prices are adjusted at infrequent intervals, CPI-S(ticky). Using this index, Erlandsen (2014) finds that price changes for goods and services whose prices are updated infrequently reflect forward-looking expectations to a larger degree than CPI as a whole, meaning this part of the price index is better at forecasting future inflation. Following from this, the inflation expectations could be assumed to be unbiased with respect to this index, but that is not what I find. Conversely, the unbiasedness-hypothesis is strongly rejected in all cases (with households as a surprising exception). The share variation in that index that expectations can explain, however, is relatively large, and β usually comes close to one.

7.3 VAR estimation of inflation and survey expectations

In the time series regression framework, predictive ability of inflation expectations can be represented by inflation expectations *Granger causing* actual inflation. This concept uses the sequential nature of time series data, namely the quality that past values of the variables are pre-determined, if the regression errors are serially independent, so that any statistical relationship between variables that cross time periods necessarily imply causal direction from the pre-determined variable to the other. In this context, testing for Granger-causality will shed light on whether inflation expectations contain more information about future inflation than past inflation does alone, which would be the case if inflation expectations actually determine what inflation will be; a central proposition in macroeconomic theory. Inflation expectations containing unique information about future inflation also implies that agents utilize information on other economic variables when forming their expectations of inflation; the VAR setup can therefore be said to be a proper test of whether inflation expectations are rational or not. To assess whether survey expectations Granger-cause actual inflation, Mehra (2002) specifies two equations that relates realized and expected inflation, (4) and (5):

$$\Delta\pi_t = a_{10} + \lambda(\pi_{t-1} - \pi_{t-1}^e) + \sum_{k=1}^n a_{1k}\Delta\pi_{t-s} + \sum_{k=1}^n a_{2k}\Delta\pi_{t-s}^e + \epsilon_{\pi t} \quad (4)$$

$$\Delta\pi_t^e = a_{20} + \mu(\pi_{t-1} - \pi_{t-1}^e) + \sum_{k=1}^n a_{3k}\Delta\pi_{t-s}^e + \sum_{k=1}^n a_{4k}\Delta\pi_{t-s} + \epsilon_{\pi^e t} \quad (5)$$

Δ refers to the first difference of the variables. Taking the first difference between the

variables allows for finding the effect that a change in one variable has on the change in the other. λ and μ are coefficients of the *error correction mechanism*, which delivers the long term reversion to the other variable in case of a *cointegrating relationship*.⁴⁰ The coefficients measure the potential speed of convergence. Lags of both variables, up to the n -th lag, with corresponding coefficients, also turn up on the right hand side in both equations. If any of the a_{ik} 's ($i \in [1, 4]$) are different from zero, inflation or inflation expectations are dependent on its own or the other's history. The error terms are assumed to have zero mean and constant variance, but are allowed to be interdependent

Mehra (2002) estimates the system of equations by OLS, while I have estimated the equations jointly in a VAR, as expressed in equation (6). OLS-estimation and estimation of the VAR give identical coefficients, but the variance-covariance matrix of the error terms in the VAR allow for non-zero diagonal elements, that is, the error term in each equation is allowed to be correlated with the error term in the other. This changes the standard errors somewhat. Results from this estimation are found in table 13. The system of equations that (4) and (5) is represented in matrix notation in equation (6)

$$\mathbf{\Pi}(L)\Delta\mathbf{Y}_t = \mathbf{c} + \mathbf{\Lambda}' \begin{bmatrix} 1 & -1 \end{bmatrix} \mathbf{Y}_{t-1} + \epsilon_t \quad (6)$$

Where $\mathbf{\Pi}(L) = \mathbf{I}_n - \mathbf{\Pi}_1 L - \dots - \mathbf{\Pi}_4 L^4$, L is the lag operator, and $\mathbf{\Pi}$ is a vector of lag coefficients. $\mathbf{Y}_t' = [\pi_t \quad \pi_t^e]$, that is, the vector of the variables in the VAR, while $\mathbf{\Lambda}$ is the vector of ECM-coefficients, and ϵ_t a vector of the error terms.

Allowing for the co-movement of inflation and expectations through the ECM-term is motivated by the hypothesis that expectations are rational, because if agents realize that they make errors in their predictions, they would over time learn to utilize the information in their prediction errors, and let expectations and inflation move together in the long run. Similarly, the determining effect that expectations have on realized inflation, according to theory, would make inflation move towards expectations. From table 13, the ECM coefficient in equation (4) is uniformly significant and negative. This does at first sight provide support for the existence of a cointegrating relationship between inflation expectations and realized inflation, but a glance at figure 2 does suggest another reason for this result. It could be that if the expectations part of the ECM is relatively constant, a high value of inflation leads to a more negative change in inflation in the next period (the dependent variable),

⁴⁰Cointegration means the variables move together in the long run, that one or both revert towards the other if other influences makes them drift apart.

perhaps because of monetary policy, or reversion to the mean. This contributes greatly to the test of the lag coefficients of the survey expectations variable leading to rejection of the null hypothesis that they are jointly equal to zero, as the ECM coefficient also features in this test. Stata's test of Granger causality (`vargranger`), reported just below, which only tests the lag coefficients, leads to rejection less often. The first test therefore suggests that the survey measures Granger-cause inflation, but this might rest on erroneous foundations.

In equation (4), if the a_2 -coefficients are significantly different from zero, it means that survey expectations contain information about future inflation beyond what is inherent in the history of inflation itself. The opposite is true for equation 5: if the a_4 -coefficients are significant, past inflation contains information about survey expectations beyond what is contained in past values of survey expectations. The sum of the lag coefficients on household expectations are not significantly different from zero for any of the inflation measures. The experts' lag coefficients regarding CPI-ATE-I is positive and significant, lending a bit more support to the proposition that survey expectations Granger-cause inflation, i.e. there is predictive power in the survey expectations. Overall, however, these results do not give grounds for optimism regarding survey forecasts' ability to predict inflation, as might be expected after the results from the bias test performed above. Parts of these results may be due to the relatively short sample period available for Norwegian survey expectations. In comparison, the Michigan survey, which Mehra (2002) makes use of, has observations from several decades. This means the Michigan survey also covers the time period where inflation in the US was reduced from the very high levels of the 70s and 80s, meaning there are large movements in the time series of inflation, which are also found in inflation expectations. It might be that survey measures of expectations are too crude to catch the smaller movements in inflation that characterize inflation in Norway during the time included in the survey sample.

Regarding the influence of actual inflation on survey expectations, there does not seem to be any long term cointegrating relationship going in that direction. The tests of the lag coefficients alone and together with the ECM-term agree more in this case, however, and there seems to be evidence that inflation Granger-causes inflation expectations, which implies that there is a backward-looking element in inflation. Past inflation can add to the predictive accuracy of inflation expectations more than what past inflation expectations can on its own.

Table 6 on the next page contains the estimation results just described. For each of the

three groups that I have considered, there are two panels, one for each of equation (4) and (5). Listed vertically are the estimated coefficients of the ECM and the sum of coefficients of the opposite dependent variable. Then follows tests of the joint restriction that these are equal to zero, and that the coefficients on the opposite variable is equal to zero. The estimation is repeated for different inflation measures.

Table 13: Test of rationality

		CPI	CPI-ATE	CPI-ATE-I	CPI-S
Households					
π dep. var.	λ	-.4094 (0.003)***	-.1518 (0.004)***	-.1563 (0.003)***	-.1247 (0.074)**
	S1	-.300 (0.669)	-.0248 (0.9033)	-.0248 (0.821)	-1.546 (0.588)
	χ_1^2 (ecm & lags)	13.98**	20.88***	17.44***	5.43
	χ_1^2 (lags)	5.196	10.62 **	7.356	1.9182
	μ	.0531 (0.427)	.0444 (0.62)	.0675 (0.439)	.0389 (0.668)
π^e dep. var.	S2	0.669 (0.816)	.1936 (0.584)	.1936 (0.282)	-.21406 (0.295)
	χ_2^2 (ecm & lags)	25.10***	3.48	3.38	2.65
	χ_2^2 (lags)	23.386 ***	2.968	1.247	1.4331
	μ	.0441 (0.444)	-.0005 (0.994)	.0177 (0.802)	-.0695 (0.295)
	S2	0,0398 (0.7341)	0,418 (0.027)**	.3940 (0.0139)**	-.2140 (0.108)
π^e dep. var.	χ_2^2 (ecm & lags)	12.12***	15.33***	15.02**	10.60*
	χ_2^2 (lags)	7.9577*	14.242***	10.304**	10.596**
	μ	.0441 (0.444)	-.0005 (0.994)	.0177 (0.802)	-.0695 (0.295)
	S2	0,0398 (0.7341)	0,418 (0.027)**	.3940 (0.0139)**	-.2140 (0.108)
	χ_2^2 (ecm & lags)	12.12***	15.33***	15.02**	10.60*
	χ_2^2 (lags)	7.9577*	14.242***	10.304**	10.596**
Economists					
π dep. var.	λ	-.5026 (0.003)***	-.2080 (0.005)***	-.2540 (0.001)***	-.2252 (0.01)**
	S1	-.01720 (0.984)	.399 (0.2476)	.6672 (0.0563)*	-1.546 (0.085)*
	χ_1^2 (ecm & lags)	19.11***	12.58 **	14.82**	9.31*
	χ_1^2 (lags)	7.2457	4.9864	6.6856	3.7376
	μ	.0441 (0.444)	-.0005 (0.994)	.0177 (0.802)	-.0695 (0.295)
π^e dep. var.	S2	0,0398 (0.7341)	0,418 (0.027)**	.3940 (0.0139)**	-.2140 (0.108)
	χ_2^2 (ecm & lags)	12.12***	15.33***	15.02**	10.60*
	χ_2^2 (lags)	7.9577*	14.242***	10.304**	10.596**
	μ	.0441 (0.444)	-.0005 (0.994)	.0177 (0.802)	-.0695 (0.295)
	S2	0,0398 (0.7341)	0,418 (0.027)**	.3940 (0.0139)**	-.2140 (0.108)
π^e dep. var.	χ_2^2 (ecm & lags)	12.12***	15.33***	15.02**	10.60*
	χ_2^2 (lags)	7.9577*	14.242***	10.304**	10.596**
	μ	.0441 (0.444)	-.0005 (0.994)	.0177 (0.802)	-.0695 (0.295)
	S2	0,0398 (0.7341)	0,418 (0.027)**	.3940 (0.0139)**	-.2140 (0.108)
	χ_2^2 (ecm & lags)	12.12***	15.33***	15.02**	10.60*
	χ_2^2 (lags)	7.9577*	14.242***	10.304**	10.596**
Business executives					
π dep. var.	λ	-.5275 (0.001)***	-.2792 (0.000)***	-.2095121 (0.006)***	-.1705 (0.036)**
	S1	-1.5469 (0.005)***	-.5223 (0.013)**	-.13816 (0.5315)	-1.546 (0.9965)
	χ_1^2 (ecm & lags)	21.06***	18.42 ***	17.34***	7.44
	χ_1^2 (lags)	10.124 **	7.040	5.3351	1.980
	μ	.7730 (0.275)	-.1012 (0.219)	-.1030 (0.319)	-.08232 (0.336)
π^e dep. var.	S2	-.21406 (0.144)	-.1723 (0.418)	.01780 (0.93)	-.21406 (0.630)
	χ_2^2 (ecm & lags)	21.06***	23.92***	4.07	4.68
	χ_2^2 (lags)	.917***	21.37***	3.1356	4.356
	μ	.7730 (0.275)	-.1012 (0.219)	-.1030 (0.319)	-.08232 (0.336)
	S2	-.21406 (0.144)	-.1723 (0.418)	.01780 (0.93)	-.21406 (0.630)
	χ_2^2 (ecm & lags)	21.06***	23.92***	4.07	4.68
	χ_2^2 (lags)	.917***	21.37***	3.1356	4.356

1: Sum of coefficients on $\Delta\pi^e$, S2: Sum of coefficients on $\Delta\pi$. Lag length 4. P-values in the parantheses. * significant at 10 %, ** significant at 5%, *** significant at 1%

8 Relationship between the survey measures

The standard theory on macroeconomic expectations does not differentiate between the expectations of different agents. The various groups are all asked about their estimate of the same variable: CPI inflation. If all agents were rational, their expectations of this variable should coincide. If we assume that the observed diversity in inflation expectations is due to different access to information, this could perhaps be systematically reflected in the respondents' estimates, for instance by information dispersing throughout the economy from the *most* informed groups to the *least* informed. A model that incorporates this idea is analyzed by Carroll (2003). In the model, economic agents update their beliefs about the economy by reading newspaper articles, where forecasts of the variables of interest are published. The agents do not perform the forecasting themselves.⁴¹ The assumption that agents do not necessarily employ all information they possess, but rely solely on one source for belief updating (i.e. by reading the newspaper), is an approximation that probably does not represent the complete expectations formation process of households, but it is an approximation that secures analytical tractability. In this section, I will perform an analysis of the Norwegian survey data inspired by the model of Carroll (2003). I limit my attention to the survey expectations of households and experts, and examine whether the households' expectations contain elements of past forecasts from professional.

In the model, a λ share of agents is assumed to register the latest information about professional forecasts given in the most recent newspapers each quarter. The remaining $1 - \lambda$ share simply use the last information they acquired to extrapolate expectations forward. Newspapers are assumed to contain a forecast of quarterly inflation.⁴² I let π_t^e denote the aggregate quarterly inflation expectation in period t . $\pi_{t|t-s}^f$ is the quarterly inflation forecast for period t published in the newspaper at $t - s$. The updating-behavior of agents therefore suggest the following relationship between expectations and news forecasts:

$$\pi_{t+1|t}^e = \lambda \pi_{t+1|t}^f + (1 - \lambda)(\lambda \pi_{t+1|t-1}^f + (1 - \lambda)(\lambda \pi_{t+1|t-2}^f + \dots + (1 - \lambda)\lambda \pi_{t+1|0}^f)) \quad (7)$$

⁴¹The main relationship derived from this model is identical to the one in Mankiw and Reis (2001), where the stickiness is assumed to arise from cost of updating information, while agents are rational.

⁴²Carroll (2003) imposes a structure on agents' beliefs about the inflation process that makes the *yearly* inflation rate equal to four times the *quarterly* rate, so although it is the yearly inflation rate that in reality (and in the data) is reported by forecasters and in the news, agents can derive the one from the other. Under these assumptions, 12 months ahead inflation expectations can therefore be used in the empirical analysis.

The agents believe experts cited in newspapers are able to forecast inflation one quarter ahead, and that inflation develops according to a *random walk* after that. The forecast of inflation the next quarter is therefore the best forecast of subsequent quarters, i.e. $\pi_{t+1|t-1}^f = \pi_{t|t-1}^f$, $\pi_{t+1|t-2}^f = \pi_{t|t-2}^f$ and so on. By substituting into (7), the recursive structure lets me write the evolution of inflation expectations as:

$$\pi_{t+1|t}^e = \lambda \pi_{t+1|t}^f + (1 - \lambda) \pi_{t|t-1}^e \quad (8)$$

The resulting equation shows that the aggregate inflation expectation is a weighted average of the rational expectation based on *up-to-date* information, and aggregate inflation expectations made one quarter ago.

If a source of expectations reported in newspaper articles can be identified, the equation can be estimated. Carroll (2003) argues that newspapers get their information by interviewing professionals working in financial institutions and academia. One issue with his theory is that it only allows for a single, unified, inflation forecast that the households are assumed to understand and remember for as long as they go without updating their information sets. In reality, experts disagree over the future path of inflation, and newspapers do not typically report an average of the forecasts but forecasts made by single professionals.

The model that I will later estimate differs from equation (8) in that it also includes the *lagged* experts' forecast:

$$\pi_{t+1|t}^e = \lambda \pi_{t+1|t}^f + \gamma \pi_{t|t-1}^e + \mu \pi_{t|t-1}^f \quad (9)$$

Equation (9), can be derived from a similar theoretical argument as above, with the added assumption that a μ share of agents for some reason get hold of the experts' forecast made one period ago instead of the current one. Then, a $(1 - \lambda - \mu) = \gamma$ share of the agents continue to use information they acquired in prior periods. The addition of a share of agents who get access to outdated information could reflect that there are some groups in the economy that are privileged with real-time access to information about events in the economy, while another share μ hearing about the news with a lag. At any rate, the only practical consequence of this assumption is that the share of agents who possess last periods' forecast changes from $(1 - \lambda)\lambda$ to $(1 - \lambda - \mu)\lambda + \mu$, i.e. it is only a quantitative change in the expectations formation process (which is unquantifiable because the parameters are unknown).

The reason for this addition is that (9) has the form of an Autoregressive Distributed Lag-model, an ADL(1,1), which is a widely used method in analysing cointegrated variables. I take this approach because the theoretical model that I have adapted from Carroll (2003) predicts that expectations of professional forecasters and households move together in the long run. This can be seen by rewriting (9), by adding and subtracting a few terms:

$$\pi_{t+1|t}^e - \pi_{t|t-1}^e = (\gamma - 1)\pi_{t|t-1}^e + (\mu + \lambda)\pi_{t|t-1}^f + \lambda(\pi_{t+1|t}^f - \pi_{t|t-1}^f) \quad (10)$$

Then, by denoting the change in expectations and forecast from one period to another with a Δ , and some additional manipulation, I arrive at:

$$\Delta\pi_{t+1|t}^e = (\mu + \lambda)(\pi_{t|t-1}^f - \frac{1-\gamma}{\mu + \lambda}\pi_{t|t-1}^e) + \lambda\Delta\pi_{t+1|t}^f \quad (11)$$

$$\Delta\pi_{t+1|t}^e = \phi(\pi_{t|t-1}^f - \beta\pi_{t|t-1}^e) + \lambda\Delta\pi_{t+1|t}^f \quad (12)$$

Where $\phi = \mu + \lambda$, $\beta = \frac{1-\gamma}{\mu+\lambda}$. Equation (12) states that the change in household expectations is in part caused by the potential divergence between the variables, i. e. an ECM-term, as well as the change in experts' forecast. If the experts' forecast should stay constant for some reason, the households' expectations should gradually converge towards the experts' forecast. The first term should ensure that households' expectations and those reported in the news do not veer too far apart, i.e. the variables are cointegrated. In practice, the ADL(1,1)-model is estimated in two steps, first by finding an estimate of β by estimating equation 13:

$$\pi_{t|t-1}^f = \beta\pi_{t|t-1}^e + u_t \quad (13)$$

The second step is to estimate the ADL(1,1) using the estimate of the adjustment coefficient β .

In the next section, I go through with the estimation of the relationships that are suggested by Carroll (2003) and my ADL(1,1)-formulation.

8.1 Estimation

In order to perform the analysis of this section, I need observations of aggregate inflation expectations and experts' inflation forecast. Time series of 12 months ahead inflation ex-

pectations is contained in the Epinion survey (see footnote 36). For the aggregate inflation expectations, I use the households' expectation measure, while the economists surveyed represent the experts in the theory.

I start by assessing whether the variables are stationary or not, before I go on to estimate equation (12). As can be seen in table 14, the Augmented Dickey-Fuller (ADF) tests do not lead to rejection of the null-hypothesis of the variables having a unit root. When I do the ADF-test on the first difference of the two variables, the null hypothesis is rejected. This leads me to believe that the expectations variables are $I(1)$, i.e. integrated of the first order. I conclude from this that further analysis using the survey measures of expectations should involve their first differences, i.e. the change in expectations, in order for it not to be invalid.

Table 14: Dickey-Fuller test for unit roots

Panel a: Inflation expectations			
π^e	test statistic	1 % Critical value	5 % Critical value
Households	-0.759	-2.620	-1.950
Experts	-0.525	-2.623	-1.950
Panel b: The change in inflation expectations			
$\Delta\pi^e$	test statistic	1 % Critical value	5 % Critical value
Households	-6.301	-2.625	-1.950
Experts	-5.316	-2.622	-1.950

Tests are augmented Dickey-Fuller tests, fitting regressions of the form $\Delta y_t = \rho y_{t-1} + \Delta \psi y_{t-1} + \varepsilon_t$, where the null hypothesis of unit root is that $\rho = 0$. The test statistic has a special distribution, the critical values are therefore shown. Because the test statistics are lower in absolute value in panel a, I do not reject the null of a unit root. For the differences in panel b, however, the test statistics are sufficiently large to reject the null hypothesis.

As discussed, the theory I have adopted from Carroll (2003) suggests that there should be a cointegrating relationship between the expectations of households and experts. I will test this proposition on the Norwegian dataset. Engle and Granger's (1987) two-step procedure lets me test whether there is a cointegrating relationship between the variables in equation (8). The first step is to estimate equation (8) by OLS. If both variables are $I(1)$, the resulting residual process would also be $I(1)$. Therefore, testing whether the residuals are stationary can reveal if the variables in the regression are cointegrated. The second step is therefore to do this by performing an Augmented Dickey-Fuller test on the residuals. The results from applying this test to the sample of households' and experts' inflation expectations is shown in panel a of table 15. The resulting test statistic is large enough in absolute value

Table 15: Engle-Granger two step procedure for testing cointegration

Panel a: Test of cointegration in equation (8)			
H0:	test statistic	1 % Critical value	5 % Critical value
I(1) Residuals	-5.460	-4.608	-3.924
Panel b: Test of cointegration in equation (13)			
H0:	test statistic	1 % Critical value	5 % Critical value
I(1) Residuals	-4.452	-4.129	-3.464

Tests reported here are from the Engle-Granger two step procedure (1987) where the null hypothesis is that the residuals from the relationship being tested is I(1). Critical values of this test differ from regular ADF critical values because the test is based on residuals, a derived variable (Sjö, 2008). Critical values are tabulated in MacKinnon (2010).

for me to reject the null-hypothesis that there is no co-integrating relationship between households' and experts' inflation expectations. I take this as evidence that there is some form of relationship between these variables that might take the form that Carroll (2003) suggests. In panel b of table 15 i apply the Engle-Granger test to the first step in estimating the ADL(1,1)-model, equation (13).

I next estimate the relationships that result from the theory I've described above. First, I estimate equation (8), to get benchmark estimates which I can compare with the conclusions that (2003) draw about the expectations formation process. He estimates the size of λ to be .27, which means households update their information about once per year on average. That is after imposing the restriction that the coefficients in equation 8 sum to one, a restriction that can't be rejected in the data, and which makes sense from the theory behind the estimation. I also test whether this is a feature of the Norwegian data. I then estimate my adaptation of the theory, the ADL(1,1) presented in equation (12).

$$\text{Households}_t = \underset{(.200)}{.728^{***}} \times \text{Experts}_t + \underset{(.135)}{.491^{***}} \times \text{Households}_{t-1} + \hat{\epsilon}_t \quad (14)$$

Equation (14) is based on Carroll's (2003) preferred model of sticky information. It excludes a constant, as that would suggest that households always believe inflation will be higher than what experts believe, which there is no theoretical grounds to believe. The equation is estimated with robust standard errors, which are displayed beneath the coefficient estimates. The restriction that the coefficient on experts' forecast and lagged household expectations equal one is rejected by an F-test, with F-score (p-value): 15.59 (0.0003). There seems to

exist a similar relationship between the forecast of experts and households' expectations as Carroll (2003) found, but I get a coefficient on experts' forecast that is larger in magnitude than what Carroll (2003) finds. This implies that information is dramatically less sticky than what is found in the American survey data. Although this seems to suggest that there exists a mechanism where information disperses from the most informed in the expectations formation process, calling it sticky information might not be appropriate if the updating frequency is this strong.

I next estimate the ADL(1,1) reparameterized as a model in differences with an ECM-term, because of my suspicion that the variables are cointegrated. This procedure consists in two steps. The first is to get an estimate of the ECM-variable by doing a simple regression based on equation (13):

$$\text{Experts}_t = .681^{***} \times \text{Households}_t + \hat{\epsilon}_t \quad (15)$$

(.013)

The ECM-variable is in practice the predicted value of the residual from equation (15). Next, this is added as a regressor in equation (12), and the equation is estimated:

$$\Delta \text{Households}_t = -.021 + .583^{**} \times (\text{Experts}_{t-1} - .681 \times \text{Households}_{t-1}) + .959^{***} \times \Delta \text{Experts}_t + \hat{\epsilon}_t \quad (16)$$

(.046) (.229) (.269)

The results in equation (16) suggest that changing experts' forecasts has an effect on the change in households' inflation expectations, and the magnitude is relatively large, with a .959 percentage point change in households' expectations for a 1 percentage point change in experts' forecast. The significant ECM-term in equation (16) suggests that the information that households' possess gradually converge to that of experts, in absence of shocks. If experts' forecast exceed .681 times households' expectations, households' expectations will begin to increase faster. Opposite, if experts' forecasts are lower, households' expectations will decrease faster.

Although the relationship between households' expectations and experts' forecasts seems to be strong, pinning down the causal direction is probably a too ambitious venture based on this analysis. The results do however align with the theory, and offers further proof for an expectations formation process that begins at the expert level, where forecasts are made, using relevant information about economic conditions, which then form the basis

of households' expectations. One implication of this relationship is that aggregate inflation expectations can be well represented by professional forecasters' views, as they either provide households with the information they use to form an expectation, or the experts themselves base their forecasts on some intuition about what aggregate inflation expectations are.

9 Conclusion

There are strong reasons to pay particular attention to the effects of expectations both in building models of the dynamic between macroeconomic variables, and in evaluations of which monetary policy measures are appropriate in a certain situation. Inflation expectations are important both in that they influence economic agents' decisions today, and in aggregate the business cycle for the whole economy, and in addition, by lending themselves for observation and analysis, expectations can help us predict what will happen to the economy and let us take measures to avoid and counteract periodical downturns in economic activity.

This thesis examines how well inflation expectations are understood in economic theory, and how successful practical methods of measuring inflation expectations are. In the theoretical part of this thesis, I have reviewed some proposals to explain the behavior of inflation expectations, as we can observe them with more or less accurate methods. Among the noteworthy characteristics of measured inflation expectations are for instance that expectations are heterogeneous between demographic groups, and that expectations become more forward-looking when inflation is costlier to ignore. Expectations models that incorporate learning, sticky information and heterogeneous estimation rules are among the contributions that have increased our understanding of how inflation expectations form to come from this branch of the literature. The fact that such models are founded on observed inflation expectations, and subsequently shown to explain the behavior of inflation expectations well, is not a guarantee that the models generalize well to inflation expectations in other monetary regimes or economic circumstances. Most of the data that is used to evaluate the relevance of such models comes from the largest American surveys of households' and professional forecasters' expectations.

In the empirical part of this thesis, I have approached the challenge of gaining an understanding of inflation expectations in three different ways. First, by taking advantage of a large data set of Norwegian households collected for this thesis, I analyzed the information

gathering habits of ordinary households regarding developments in the economy, and the knowledge they possess about inflation dynamics. I find that there is a great deal of uncertainty among the respondents about how inflation will develop over the next twelve months, uncertainty which is perhaps not reflected in the survey measures of inflation expectations in Norway. I also find that many respondents are asked to state their expectations about future inflation without being entirely sure about how inflation is affected by monetary policy, or how inflation is defined. This approach of designing an exploratory survey is inspired by the part of the literature on inflation expectations that start out from the data, either compiled through surveys or experiments, and tries to model the expectations formation process in a way that incorporates features of the data, some of which I have covered in the theoretical sections of this thesis.

Second, the existence of a Norwegian survey measuring inflation expectations over time lets me put the reliability of the theories to the test by applying it to another sample, as well as gaining possible insights into the expectation formation process in Norway. I adopt a model of sticky information, which has as its basic premise that only a share of agents in the economy get access to current information that professional forecasters communicate every period. As a result, the aggregate inflation expectations should contain elements of professional forecasts that date from earlier periods. I evaluate this hypothesis by formulating the relationship between households' expectations and experts' forecasts as an Autoregressive Distributed Lag-model, and find that there is likely a cointegrating relationship between the survey measures, as well as significant lagged dependency, which supports the hypothesis that information is transmitted with a lag to a part of the households in the economy.

Third, I start out from the idealized assumptions of the economy that macroeconomic theory builds on, and see if the observed inflation expectations behaves in accordance with those assumptions. The way that such tests have been operationalized has mainly concerned the predictive power of inflation expectations over future inflation. A finding that expectations predict future inflation well is both a justification for the assumptions that are made, as well as a sign that central banks and others can use expectations measures to good effect in forecasting the economy. In my empirical approach, I first estimate a simple relationship between expected 12 month ahead inflation and realized inflation, to establish whether the survey measures have predictive value. I find that the expectations of professional forecasters, businesses and labor organizations track the movement of a narrow element of the

Consumer Price Index relatively well, namely that composed of prices on goods that are produced domestically. This is a reasonable result, considering these prices should develop in close correspondence to fundamentals in the domestic economy, such as productivity growth and wage inflation. Second, I formulate a VAR between the survey measures and realized inflation, in order to test for Granger-causality between the variables, i.e. for whether inflation expectations contain more information about future inflation than past inflation does alone, which would be the case if inflation expectations actually determine what inflation will be; a central proposition in macroeconomic theory. Inflation expectations containing unique information about future inflation also implies that agents utilize information on other economic variables when forming their expectations of inflation; the VAR setup can therefore be said to be a proper test of whether inflation expectations are rational or not. I find that households' expectations do not Granger-cause inflation, while there is some weak evidence that expectations of businesses and economists do, for some of the inflation measures concerned.

Our understanding of inflation expectations will unquestionably remain incomplete, given the complexity of the variable's determinants. Knowledge about the process with which inflation expectations form is building, however. The continuous effort in refining the measurement methods of inflation expectations, and the increasing availability of data, will open new avenues for research on the topic. In this thesis, I have aimed at providing a synthesis of the advances on the topic so far, and apply their lessons in an analysis of inflation expectations in Norway.

References

- Akerlof, G. A., Dickens, W. T., Perry, G. L., Gordon, R. J., & Mankiw, N. G. (1996). The macroeconomics of low inflation. *Brookings papers on economic activity*, 1–76.
- Applebaum, B. (2015). Stanley fischer suggests fed will give less guidance. *The New York Times*(Feb. 27 2015). Retrieved from <http://nyti.ms/1ACUy9q>
- Armantier, O., de Bruin, W. B., Topa, G., Van Der Klaauw, W., & Zafar, B. (2011). *Inflation expectations and behavior: Do survey respondents act on their beliefs?* (Staff Report no. 509). Federal Reserve Bank of New York.
- Armantier, O., Nelson, S., Topa, G., Van Der Klaauw, W., & Zafar, B. (2012). *The price is right: Updating inflation expectations in a randomized price information experiment* (Staff Report No. 543). Federal Reserve Bank of New York.
- Ball, L., Cecchetti, S. G., & Gordon, R. J. (1990). Inflation and uncertainty at short and long horizons. *Brookings Papers on Economic Activity*, 215–254.
- Barro, R. J., & Gordon, D. B. (1983). A positive theory of monetary policy in a natural-rate model. *Journal of Political Economy*, 91. pp 589-610.
- Barsky, R. B. (1987). The fisher hypothesis and the forecastability and persistence of inflation. *Journal of Monetary Economics*, 19(1), 3–24.
- Batini, N., & Nelson, E. (2001). The lag from monetary policy actions to inflation: Friedman revisited. *International Finance*, 4(3), 381–400.
- Bernanke, B. S. (2007). *Inflation expectations and inflation forecasting*. (speech at the Monetary Economics Workshop of the National Bureau of Economic Research Summer Institute, Cambridge, Mass., July 10 2007)
- Blinder, A. S. (1999). *Central banking in theory and practice*. Cambridge, MA.: MIT press.
- Blinder, A. S., Ehrmann, M., Fratzscher, M., De Haan, J., & Jansen, D.-J. (2008). Central bank communication and monetary policy: A survey of theory and evidence. , 46(4), 910-945.
- Branch, W. A. (2004). The theory of rationally heterogeneous expectations: Evidence from survey data on inflation expectations*. *The Economic Journal*, 114(497), 592–621.
- Branch, W. A. (2007). Sticky information and model uncertainty in survey data on inflation expectations. *Journal of Economic Dynamics and Control*, 31(1), 245–276.
- Calvo, G. A. (1983). Staggered prices in a utility-maximizing framework. *Journal of monetary Economics*, 12(3), 383–398.

- Campbell, D. T. (1957). Factors relevant to the validity of experiments in social settings. *Psychological bulletin*, 54(4), 297.
- Carroll, C. D. (2003). Macroeconomic expectations of households and professional forecasters. *the Quarterly Journal of Economics*, 118(1), 269–298.
- Carvalho, C., & Nechio, F. (2014). Do people understand monetary policy? *Journal of Monetary Economics*, 66, 108–123.
- Coibion, O., & Gorodnichenko, Y. (2013). *Is the phillips curve alive and well after all? inflation expectations and the missing disinflation* (Working Paper). National Bureau of Economic Research.
- Corder, M., & Eckloff, D. (2011). International evidence on inflation expectations during sustained off-target inflation episodes. *Bank of England Quarterly Bulletin*, Q2(2011).
- Curtin, R. (1996). *Procedure to estimate price expectations* (Working Paper). University of Michigan Survey Research Center.
- de Bruin, W. B., Manski, C. F., Topa, G., & Van der Klaauw, W. (2011). Measuring consumer uncertainty about future inflation. *Journal of Applied Econometrics*, 26(3), 454–478.
- de Bruin, W. B., Potter, S., Rich, R. W., Topa, G., & Van der Klaauw, W. (2010). Improving survey measures of household inflation expectations. *Current Issues in Economics and Finance*, 16(7).
- de Bruin, W. B., Van der Klaauw, W., Downs, J. S., Fischhoff, B., Topa, G., & Armantier, O. (2010). *The effect of question wording on reported expectations and perceptions of inflation* (Staff Report no. 443).
- Dieffenthaler, L. (2014). *Optimal central bank transparency – assessing the holy grail of monetary policy*. Norway.
- Ehrmann, M. (2014). *Targeting inflation from below - how do inflation expectations behave?* (Working Paper no. 52). Bank of Canada.
- Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: representation, estimation, and testing. *Econometrica*, 55(2), 251–276.
- Erlandsen, S. (2014). *Sticky prices and inflation expectations in norway* (Staff Memo no. 15). Norges Bank.
- Forder, J. (2010). Friedman’s nobel lecture and the phillips curve myth. *Journal of the History of Economic Thought*, 32(03), 329–348.
- Fracasso, A., Genberg, H., & Wyplosz, C. (2003). *How do central banks write? an evaluation*

- of inflation reports by inflation targeting central banks* (Geneva Reports on the World Economy Special Report 2). International Center for Monetary and Banking Studies, Centre for Economic Policy Research (CEPR) and Norges Bank.
- Friedman, B. M. (1979). Optimal expectations and the extreme information assumptions of ‘rational expectations’ macromodels. *Journal of Monetary Economics*, 5(1), 23–41.
- Friedman, M. (1968). The role of monetary policy. *American Economic Review*, 58(1), 1–17.
- Fuhrer, J. C. (2009). *Inflation persistence* (Working Paper). Federal Reserve Bank of Boston.
- Gordon, R. J. (1982). Price inertia and policy ineffectiveness in the united states, 1890–1980. *Journal of Political Economy*, 90(6), 1087–1117.
- Granger, C. W. (1980). Testing for causality: a personal viewpoint. *Journal of Economic Dynamics and control*, 2, 329–352.
- Granger, C. W., & Newbold, P. (1974). Spurious regressions in econometrics. *Journal of econometrics*, 2(2), 111–120.
- Grant, A. P., & Thomas, L. B. (1999). Inflationary expectations and rationality revisited. *Economics Letters*, 62(3), 331–338.
- Holleman, B. (1999). Wording effects in survey research using meta-analysis to explain the forbid/allow asymmetry. *Journal of Quantitative Linguistics*, 6(1), 29–40.
- Hyvonen, M. (2004). *Inflation convergence across countries* (Research Discussion Paper 4-2004). Reserve Bank of Australia.
- Jansen, D.-J., & De Haan, J. (2007). *The importance of being vigilant: Has ecb communication influenced euro area inflation expectations?* (Working Paper). CESifo.
- Jimenez-Buedo, M., & Miller, L. M. (2010). Why a trade-off? the relationship between the external and internal validity of experiments. *Theoria*, 25(3), 301–321.
- Johnson, D. R. (2002). The effect of inflation targeting on the behavior of expected inflation: evidence from an 11 country panel. *Journal of Monetary Economics*, 49(8), 1521–1538.
- Kahneman, D. (1973). *Attention and effort*. Englewood Cliffs, New Jersey: Prentice-Hall.
- Keynes, J. M. (1936). *The general theory of employment, interest and money*. Cambridge: Macmillan Cambridge University Press.
- Kydland, F. E., & Prescott, E. C. (1977). Rules rather than discretion: The inconsistency of optimal plans. *The Journal of Political Economy*, 85(3), 473–492.

- Levin, A. T., Gürkaynak, R., Marder, A. N., & Swanson, E. T. (2007). Inflation targeting and the anchoring of inflation expectations in the western hemisphere. In F. Mishkin & K. Schmidt-Hebbel (Eds.), *Series on central banking, analysis, and economic policies x: Monetary policy under inflation targeting*. Santiago, Chile: Central Bank of Chile, 2007.
- Linville, P. W., Fischer, G. W., & Fischhoff, B. (1993). Aids risk perceptions and decision biases. In J. B. Pryor & G. D. Reeder (Eds.), *The social psychology of hiv infection*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.
- Lucas Jr, R. E. (1976). Econometric policy evaluation: A critique. In K. Brunner & A. H. Meltzer (Eds.), *Carnegie-rochester conference series on public policy* (Vol. 1, pp. 19–46). Amsterdam, The Netherlands.
- MacKinnon, J. G. (2010, Jan). *Critical Values for Cointegration Tests* (Working Papers No. 1227). Queen’s University, Department of Economics.
- Madeira, C., & Zafar, B. (2012). *Heterogeneous inflation expectations and learning* (Staff Report). Federal Reserve Bank of New York.
- Mankiw, N. G. (2001). The inexorable and mysterious tradeoff between inflation and unemployment. *The Economic Journal*, 111(471), 45–61.
- Mankiw, N. G., & Reis, R. (2001). Sticky information versus sticky prices: a proposal to replace the new keynesian phillips curve. *Quarterly Journal of Economics*, 117(4), 1295–1328.
- Mehra, Y. P. (2002). Survey measures of expected inflation: revisiting the issues of predictive content and rationality. *Economic Quarterly-Federal Reserve Bank of Richmond*, 88(3), 17–36.
- Mishkin, F. S., & Schmidt-Hebbel, K. (2007). *Does inflation targeting make a difference?* (Working Paper). National Bureau of Economic Research.
- Muth, J. F. (1961). Rational expectations and the theory of price movements. *Econometrica: Journal of the Econometric Society*, 29, 315–335.
- Neuenkirch, M., & Tillmann, P. (2014). Inflation targeting, credibility, and non-linear taylor rules. *Journal of International Money and Finance*, 41, 30–45.
- Orphanides, A., & Williams, J. C. (2005). The decline of activist stabilization policy: Natural rate misperceptions, learning, and expectations. *Journal of Economic dynamics and control*, 29(11), 1927–1950.
- Phillips, A. W. (1958). The relation between unemployment and the rate of change of

- money wage rates in the united kingdom, 1861–19571. *economica*, 25(100), 283–299.
- Roberts, J. M. (1995). New keynesian economics and the phillips curve. *Journal of money, credit and banking*, 27(4), 975–984.
- Rogoff, K. (1985). The optimal degree of commitment to an intermediate monetary target. *The quarterly journal of economics*, 100, 1169–1189.
- Sargent, T. J. (1982). The ends of four big inflations. In *Inflation: Causes and effects* (pp. 41–98). University of Chicago Press.
- Say, J. B. (1855). *A treatise on political economy*. Philadelphia: Lippincott Grambo & Co.
- Schmidt, S., & Nautz, D. (2010). *Why do financial market experts misperceive future monetary policy decisions?* (Discussion Paper 10-045). ZEW-Centre for European Economic Research.
- Sjö, B. (2008). *Testing for unit roots and cointegration* (Unpublished).
- Statistics Norway. (2015). *Norsk mediebarometer 2014* (Tech. Rep.). Retrieved from <https://ssb.no/medie>
- Strandgaard, P. B., & Andersen, N. (2015). *Politisk fokus på arbejdsudbuddet er sort snak for danskerne* (Tech. Rep.). Cevea.
- Svensson, L. E. (1995). Optimal inflation targets, conservative central banks, and linear inflation contracts. *The American Economic Review*, 87(1), 98–114.
- Svensson, L. E. (1997). Inflation forecast targeting: Implementing and monitoring inflation targets. *European Economic Review*, 41(6), 1111–1146.
- Svensson, L. E. (2003). What is wrong with taylor rules? using judgment in monetary policy through targeting rules. *Journal of Economic Literature*, 41(2), 426–477.
- Svensson, L. E. (2013). ‘leaning against the wind’ leads to higher (not lower) household debt-to-gdp ratio. *manuscript, SIFR, Swedish House of Finance*.
- The Economist. (2013). *In dollars they trust*. *The Economist*, 27 April 2013. Retrieved from <http://econ.st/11GnXvC>
- Ullrich, K. (2008). Inflation expectations of experts and ecb communication. *The North American Journal of Economics and Finance*, 19(1), 93–108.
- Vega, M., & Winkelried, D. (2005). Inflation targeting and inflation behavior: a successful story? *International Journal of Central Banking*, 1(3), 153–175.
- Wicksell, K. (1936). *Interest and prices* (Translated by RF Kahn, 1898 ed.). London: MacMillan.

Appendix

Original survey questions used in section 6

Hender det at du følger med på økonominyheter ?

1. Nei
2. Månedlig eller sjeldnere
3. Ukentlig
4. Daglig
5. Usikker

Hvilket av følgende 5 alternativer tror du vil få størst konsekvenser for økonomien i Norge i 2015 ?

1. Kronekurs
2. Oljepris
3. Arbeidsledighet
4. Lønnsvekst
5. Inflasjon
6. Vet ikke

Veksten i konsumprisindeksen – som er prisutviklingen på varer i Norge, var i 2014 på 2,0 %. Tror du denne blir høyere, lavere eller den samme i 2015 ?

1. Høyere
2. Lavere
3. Den samme
4. Vet ikke

Kan du forklare hva inflasjon er ?

1. Trykking av penger
2. Prisvekst
3. Prisvekst som er høyere enn normalt

4. Vet ikke

Dersom Norges Bank setter ned renten, hva tror du da skjer med inflasjonen ?

1. Forblir uendret
2. Går opp
3. Går ned
4. Vet ikke